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CONTENTS

Miscellaneous

UDC 624.156; 624.154.001.24

Specifics of Design of Pile Elements of Power Engineering Project Foundations

18610160 Moscow VESTNIK MASHINOSTROYENIYA in Russian No 10, Oct 88 pp 77-78

[Article by Engineer L. A. Berdichevskiy, I. P. Boyko, candidate of technical sciences, R. V. Vasyagin, engineer, A. Ye. Delnik, candidate of technical sciences and L. G. Lukina, engineer]

[Abstract] Power-engineering projects are much larger than the lengths of the individual piles which may be used in their foundations, and the operation of the piles in the foundation differs significantly from the operation of an individual file. Due to uniform settlement, interior piles transmit practically no load through their side surfaces, requiring that different principles be used to design them. The method of finite elements is particularly suited to this work. Software has been written in the USSR and abroad for solution of problems of geomechanics and foundation design by the method of finite elements. A test field has been set up in an area with 20 m of sandy lome followed by 32 m of chalk above a basalt basement. Piles were tested in the area with various combinations of horizontal and vertical loadings. The tests indicated that a drilled and driven pile 33.4 m long and 1.2 m in diameter under both vertical and horizontal loading and a load-bearing capacity of 900 kN, 30 percent greater than the load capacity assuming horizontal loads alone. Figures 2, references 3: Russian.

UDC [621.313.322-82]-7

Protection of Hydraulic Generator Water Cooling Systems at Sayano-Shushenskaya Hydroelectric Power Plant From Corrosion and Deposits

18610154 Moscow ELEKTRICHESKIYE STANTSII in Russian No 8, Aug 88 pp 87-88

[Article by L. M. Kulak, engineer, V. I. Bryzgalov, candidate of technical sciences, V. A. Stafiyevskiy, A. N. Mitrofanov, N. K. Milyayev, N. N. Stulov, engineers, V. G. Palmskiy, candidate of chemical sciences, R. N. Zhidov, engineer, A. M. Sukhotin, doctor of chemical sciences, V. A. Zaytsev, candidate of technical sciences, Yu. Yu. Yesipenko, engineer, Sayano-Shushenskaya Hydroelectric Power Plant, "Elektrosila" Power Engineering Association, Leningrad Institute of Power Engineering]

[Abstract] Measurements were performed on the rate of corrosion of cc pper and the quantity of copper oxide deposit in cooling channels in the windings of hydroelectric generators protected by corrosion and deposition inhibitors containing formaldehyde, benzotriazole and monoethanolamine. The use of the combined inhibitor was found to decrease the quantities of deposits in comparison to a control channel without inhibitor by a factor of 15 in the slot portion, 13 in the lower head portion, 26 in the upper portion. The greatest protective effect is observed in the most heavily stressed areas of the winding, which are most subject to clogging by deposits. References 7: Russian.

UDC 62-5.681.3

Testing System for Automatic Regulation of Power Unit, Based on Remikont Devices

18610137a Moscow TEPLOENERGETIKA in Russian No 10, Oct 88 pp 11-16

[Article by V. A. Bilenko, candidate of technical sciences, Yu. I. Gomzyakov, S. S. Zorina, V. G. Krikotin, A. M. Kuzmichev and A. A. Stulgite, engineers, and L. M. Shalman, candidate of technical sciences, Soyuztekhenergo; All-Union Institute of Heat Engineering imeni F. E. Dzerzhinskiy; Litovskaya Regional Electric Power Plant; Scientific Research Institute of Thermal Instrumentation]

[Abstract] The remikont R-100 was among the first domestic microprocessor devices for process control. An automatic regulation system for a 300 MW power unit was developed to study the expediency of using remikont devices in power engineering. In 1986, a distributed automatic power unit regulation system, in which all regulation except power level was performed with remikonts, was approved. Later, due to various problems, regulation of the unit was transferred to a different type of equipment. This article lists the most characteristic failures of the remikont devices, their reasons for occurrence and suggested corrective measures. The remikont devices are concluded to have definite advantages over analog equipment, but definite hardware limitations, including insufficient tolerance for noise and temperature variation. Remikont devices as delivered also have other limitations, resulting from low manufacturing quality. The devices do not match the quality levels of similar foreign devices. A number of the problems have been eliminated in later models, but successful introduction will require organization of a repair service, training of personnel, development of standard power unit control systems and recommendations for generation of planning documentation. Figures 4, references 3: Russian.

UDC 681.5.015 [621.362:537.84]

Method of Experimental Determination of Dynamic Combustion Chamber Characteristics in MHD-Generator Installation

18610137b Moscow TEPLOENERGETIKA in Russian No 10, Oct 88 pp 48-51

[Article by A. I. Plavinskiy, engineer, Institute of Computer Technology, USSR Academy of Sciences]

[Abstract] Experimental studies of an MHD-generator combustion chamber were performed. In each experiment, the transport delay time, excess oxidant content and natural gas consumption were determined. Based on the experimental results, equations are developed to compute the composition of combustion products. An analytic expression is derived for each experiment approximating the transfer function of the generator based on the output parameter—the excess oxidizer coefficient upon a disturbance in natural gas flow. The method suggested for experimental determination of dynamic characteristics is recommended for industrial MHD power plants. Figures 5, references 8: Russian.

Testing the Regulation System of the Turbine K-750-65/3000

18610153 Moscow ELEKTRICHESKIYE STANTSII in Russian No 8, Aug 88 pp 33-37

[Article by E. A. Lyapin, candidate of technical sciences, A. T. Yefremov, Ye. I. Serebryanik, I. A. Dezhin, and Yu. I. Ponomarenko, engineers, Sredaztekhenergo - Ignalinskaya nuclear power plant]

[Text] The K-750-65/3000 turbines are designed to work in a single circuit nuclear power plant (AES) with RBMK-1500 reactor. It is a five cylinder turbine. A two-stream high pressure cylinder is located at the center, while at either side of this there are two two-stream low pressure cylinders. The steam distribution of the turbine is by throttle. Steam is supplied across two isolating-regulating valves. After the HP cylinder, the steam with pressure of 0.45 MPa and humidity of 15 percent is sent to the steam separator-heater (SPP). After the SPP, the steam is supplied across isolating and regulating gates. The isolating valves and the isolating and regulating gates are controlled by individual two-position servomotors. The regulating valves are moved by two main servomotors across cam distributing mechanisms.

The K-750-65/3000 turbines are equipped with electro-hydraulic regulation systems (EGSR), which thanks to sophisticated electronics, enables multifunctional regulation. A traditional hydraulic regulation system is used as the backup. The hydraulic actuators of the EGSR and GSR are held in common. The EGSR is designed to control the turbine in startup, operating, and emergency modes. When the turbine assembly is engaged into the network, the EGSR works in one of three modes: RDB - maintain pressure in the separating drums; RM - maintain power of turbine unit; RCh - maintain frequency.

When the pressure in the separating drums is lowered below a certain limit, both turbines are switched to maintain the pressure with forced adjustment of the regulators.

During normal operation, one of the turbines works in RM mode, the other in RDB. When shedding load with the EGSR, a forcing signal is generated to close the valves and the system is switched to maintain a rotational frequency of 3000 rpm.

A similar description of the regulation system is given in [1] and [2].

In order to determine the dynamic qualities of the turbine unit, steam load shedding testing (closing the regulating elements with maximum speed, generator not disconnected from the network) was conducted.

The testing was done by the following procedure. The signal to close the regulating valves and gates was sent by a switch simulating disconnection of the air breaker. After the electric power was lowered to zero by the operator, the regulating gates were opened, while the regulating valves stayed shut. At the same time as the signal was sent to close the regulating elements by the operator, the high speed pressure regulator for steam release to condenser (BRU-K) was opened and the reactor power was lowered at a speed of 1 percent by acting on the set-point controller. The parameters were registered on electromagnetic oscillographs N113 with the following equipment: electric power by P0022 pickups, displacements of the servomotors by DP-T type tubular rheochords of Soyuztekhenergo design, and pressure by DT-M pickups. In order to determine the mechanical power of the turbine, the design of the standard instrument "frequency-direct current converter" (PChPT) was modified. The modification resulted in increased output power and reduced time constant of the instrument.

The transient process of shedding 759 MW is shown in Figure 1. The servomotors of the regulating valves (GSM) were closed in 0.5-0.6 s, the closing time of the regulating gates (ZR) was 0.55 s. The mechanical power (Figure 2) is changed in 0.15 s and after 0.52 s is lowered to 200 MW, staying at this level for 0.2 s, and then drops smoothly to zero in 0.8 s. The step in the transient process of power variation at the 200 MW level can be explained by the boiling of the moisture in the flow channel of the turbine unit.

The signal to open the regulating gates (Figure 1) was sent in the sixth second, the opening time taking 3.5-5 s. At the same time as the gates are opening, the electrical power increases and in the ninth second it attains 250 MW. Thereafter, for a duration of 120 s, it declines smoothly to zero. The reason for this power increase is boiling of the water in the separator-collector and the associated drain pipelines of the regenerative afterheaters.

It follows from the obtained data that the pace of power decrease on the segment from the rating to 200 MW is 1.4 unit/s, and in the remainder of the range it is 0.267 unit/s. The level of short-term overspeeding, computed by the procedure of [3], was 190 rpm. The tests demonstrated that the energy accumulated in the SPP is very sizeable and should significantly affect the processes of transition of the turbine to partial load while controlling the turbine with the system automation, as well as on the load shedding processes.

The testing for total electric load shedding provides the most information on the operation of all elements of the regulation system.

Prior to the testing, the operation of the safety automation and the tightness of the isolating and regulating valves were checked out and the static and dynamic curves were plotted.

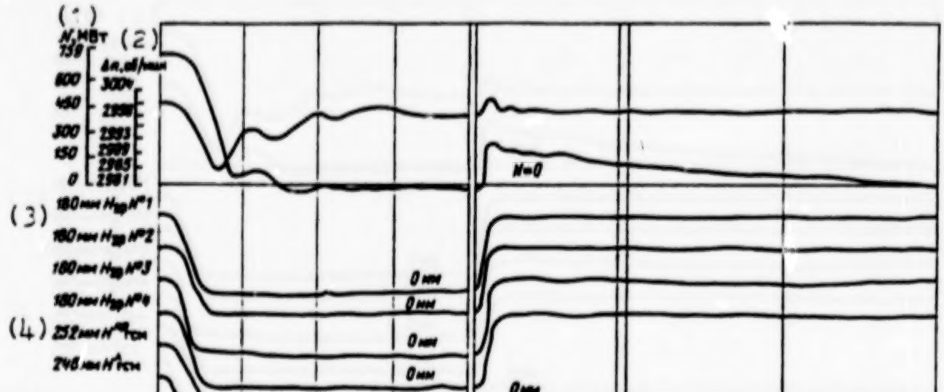

Figure 1. Steam Load Shedding Diagrams

Key: 1. N, MW 2. rpm 3. H(ZR) 4. H(GSM) 5. P(SPP), MPa 6. time, s

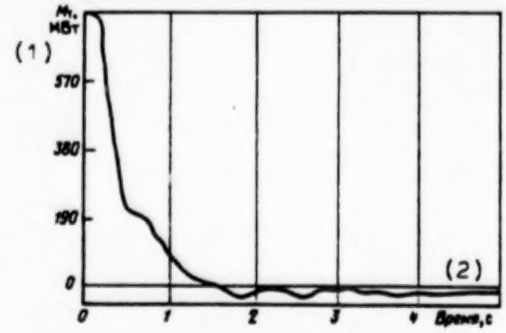

Figure 2. Chart of Mechanical Power Change Under Steam Load Shedding

Key: 1. MW 2. time, s

Figure 3 shows the results of testing the shedding of a load of 780 MW. In response to the event of disconnection of the breaker of the EGSR generator, a boosting signal was generated, resulting in the closure of the regulating valves and regulating gates with maximum speed. The speed of the turbine reached its maximum level of 3210 rpm in 1.1 s. In the 23rd second, the speed was reduced to 3000 rpm, which produced the opening of the regulating gates and a further increase in speed to 3190 rpm. When the speed increased beyond 3120 rpm, the EGSR sent a boosting signal to close the valves. There were 7 gate opening and closing processes. Such type of transient results from the relay actuator of the regulating gates. The time of the transient was 250 s. Under the initial conditions, the pressure in the SPP was 0.44 MPa; upon closure of the regulating valves and gates, it increased to 0.5 MPa, and thereafter decreased smoothly as the gates opened.

The process of oil pressure change in the EGSR and GSR lines is worthy of interest. The sending of the boosting pulse produces a sharp pressure drop in the EGSR line, as well as in the GSR line. As the regulating valves close, the pressure in the GSR line increases and produces an increase in pressure in the EGSR line. This is explained by inadequate tightness of the switching devices. As the slide valve of the speed regulator reaches the broad ports, the pressure levels in both lines decline and the valves stay open. The pressure in the protection lines during the first second increases to 2.4 MPa, and then declines to 1.6 MPa. In each cycle of oscillation, a pressure spike of 2.4 MPa and a decrease to 1.6 MPa are observed. The wave processes in the protection line probably originate at the hydraulic junctions in the high pressure collector, while the coupling to the protection line is effected through the low pressure collector and the force fluid pumps.

The testing has shown that the regulation system can successfully cope with the shedding of total electrical load. The duration of the transient is determined by the evaporation time of the SPP and is equal to 250 s. A cold operation is achieved after 7 cycles of opening and closing the gates.

Practical use of the turbine unit has demonstrated the high working reliability of the SAR. The electrical power in RM mode is maintained with an accuracy of plus or minus 5 MW, the pressure in RDB mode with plus or minus 0.02 MPa. When the protection feature for total quenching of the reactor (AZ-1) is activated, the pressure change in the separator drums does not exceed 0.5 MPa.

An investigation of the processes of turbine control from the emergency suppression system automation was done

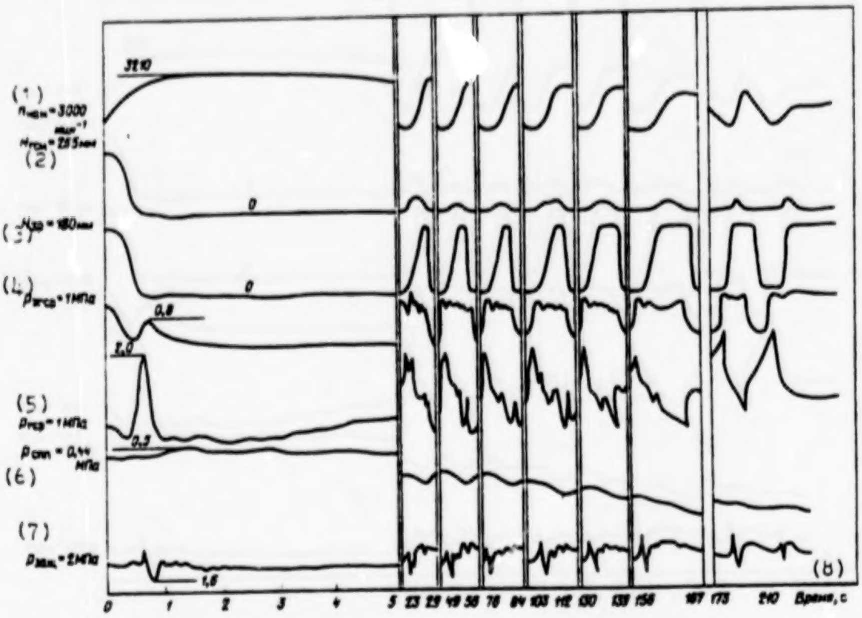

Figure 3. Electric Load Graphs: p(GSR) - Oil Pressure in the Control Line of the Hydraulic Regulation System; p(EGSR) - Oil Pressure in the Control Line of the Electrohydraulic Regulation System; p(SPP) -Pressure in the Steam Separator-Heaters; P(Protection) - Oil Pressure in the Protection Line

Key: 1. n(nom)=3000 rpm 2. H(GSM) 3. H(ZR) 4.p(EGSR)=1 MPa 5. p(GSR)=1 MPa 6. p(SPP)=0.4 MPa 7. p(protection)=2 MPa 8. time, s

with a mathematical model. The mathematical simulation was performed in accordance with [4]. The model took into account the boiling of water in the SPP, as well as the primary nonlinearities of the regulation system (variable coefficients, stops, relay elements, flow characteristics of the gates, etc.). The mathematical model was corrected from the experimental data obtained. The calculations were performed for a broad spectrum of control signals. It was ascertained that the factor limiting the pulsed unloading range is the pressure in the SPP and the level of overregulation of power as the turbine unit reaches partial loads. Control signals of rectangular shape (Figure 4) with amplitude of 3 nV and duration up to 0.3 s do not produce an increase in pressure in the SPP beyond the rated level, although the maximum degree of unloading for these pulses is 34 percent. As the duration of the pulse increases, the transient is accompanied by a buildup of pressure in the SPP and when T_p=0.5 s, it reaches the activation set-point of the protection. A satisfactory quality of transient processes with respect to the pressure in the SPP may be achieved with an exponential decay of the control signal. With time constant of the exponential curve T=3 s and amplitude at the start of the signal decay A=1.5 nV, the transient processes occur without increasing the pressure in the SPP, regardless of the duration of the rectangular signal.

The investigation established that the transition from pulsed unloading to static power limitation (prolonged unloading), as defined by the conditions of stability of the power system after the emergency, involves a substantial overregulation. This is due to the accumulation of energy in the SPP and the relay actuation of the regulating gates. The results of calculations with unloading to 25, 50 and 75% are shown in Figure 5, where it is clear that the overregulation for the turbine unit limited to 50% is 120 MW, while that for 75% is 150 MW.

Such nature of power change should be a factor in the analysis of emergency conditions of operation of the power system.

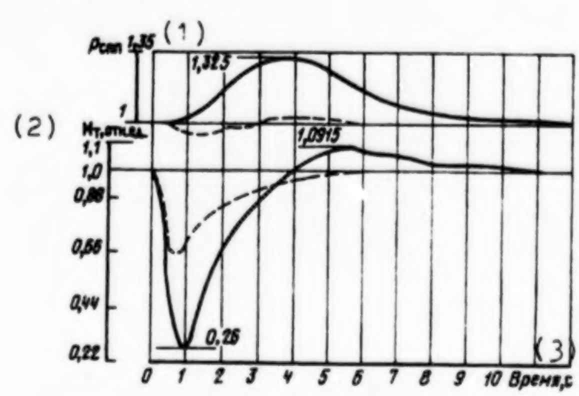

Figure 4. Diagrams of Transient Processes for a Rectangular Pulse: Solid Line, Pulse Duration 0.5 s; Broken Line, Pulse Duration 0.3 s

Key: 1. p(SPP) 2. Relative units 3. Time, s

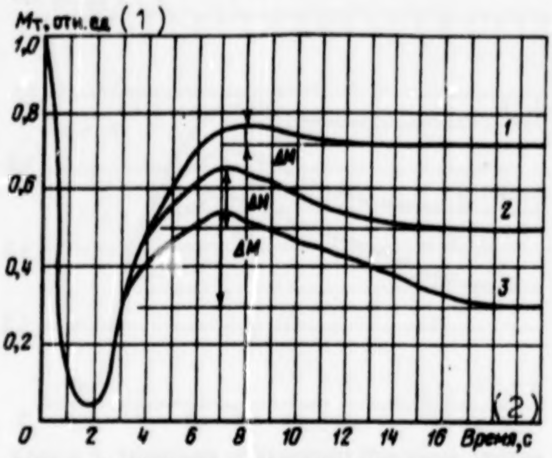

Figure 5. Diagrams of Transient Processes During Pulsed Unloading and Static Power Limitation: 1, 2, 3 - Limiting to 25, 50, 75%, Respectively; M_T - Mechanical Power of Turbine; M - Level of Overregulation

Key: 1. Relative units 2. Time, s

It should be noted that an overregulation with respect to static power limitation was also observed during pulsed unloading in the K-500- 65/3000 turbines [5].

Conclusions

1. Testing of the prototype of the regulation system of the K-750- 65/3000 turbine demonstrated that the basic design philosophy is valid. The system provides an adequate quality of regulation of all parameters and successfully deals with the shedding of the full electrical load.

2. In order to diminish the mutual influence of the GSR and EGSR lines, it is desirable to modify the switching devices.

3. If the K-750-65/3000 turbine units are to be used for emergency control, the peculiarities of the dynamic characteristics of the turbine and the regulation system should be taken into account.

4. In the opinion of the authors, the actuation of the regulating gates for newly released turbine units should have proportional control.

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UDC 539.3

Parametric Oscillations of Ribbed Cylindrical Shell Together With Attached Beam
18610156 Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 24 No 9, Sep 88 (manuscript received 30 Jun 87) pp 47-55

[Article by V. G. Palamarchuk, Institute of Mechanics, Ukrainian Academy of Sciences, Kiev]

[Abstract] A closed circular cylindrical shell is studied, carrying a beam on two supports located along a generatrix and attached to the inside of the shell. One of the supports prevents longitudinal movement, the other, at the other end of the beam, does not. The shell is regularly reinforced by stringers and rings. Longitudinal, uniformly distributed loads are applied to the ends of the shell, consisting of a static component plus a dynamic component with a known frequency. The problem of determining the critical excitation frequency is solved on the assumption that the rigidity of the shell in the tangential plane is much greater than its rigidity in the radial direction, the subcritical stress-strain state of the shell is homogeneous and zero-moment, the ribs assure equal bending along contact lines, the stringer twist and bend in the longitudinal diametric planes, the rings in their own plane Graphs are presented of the change in minimum critical excitation frequency as a function of position of the beam along with the generatrix with all other system parameters unchanged. The curves show that the critical frequencies computed on the basis of a model considering the discrete placement of the stringers and rings are not only lower than those computed from the orthortropic shell model, but also depend more strongly on the distance from the ends of the shell at which the beam is attached. Figures 4, references 6: Russian.

UDC 534.232

Influence of Shape of Nonradiating Piezoceramic Converter Cover Plate on Amplitude-Frequency Characteristic
18610151 Minsk DOKLADY AKADEMII NAUK BSSR in Russian Vol 32 No 10, Oct 88 (manuscript received 21 Oct 87) pp 914-916

[Article by I. A. Samarin and M. D. Tyavlovskiy, Minsk Radio Engineering Institute]

[Abstract] Ultrasonic equipment for cleaning and decreasing precision electronic, optical and mechanical parts must have great uniformity of action of the ultrasonic oscillations on the object to be cleaned. It is therefore desirable to place several smaller (40-75 W) transducers on the wall and bottom of an ultrasonic cleaning bath rather than one large transducer. The authors have developed a piezoceramic converter consisting of a pack of longitudinally polarized piezoceramic rings located between two metal cover plates for this purpose. One end plate is conical in shape, expanding the frequency band of electronic oscillations converted to mechanical oscillations. Comparative tests were undertaken of the new transducer and models without the conical end plate. The unit showed good stability and reliability of operation, and the acoustical load provided by the cone expanded the range of conversion for a cone with an angle of up to 8-10°, while sharper angles greatly decreased the mechanical efficiency of the transducer. Figures 2, reference 1: Russian.

UDC 539.3:621.81

Simplified Statement of Physically Nonlinear Problem of Designing Thin-Layer Rubber-Metal Elastic Elements
18610155 Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 24 No 9, Sep 88 (manuscript received 5 Jun 86) pp 89-96

[Article by S. I. Dyminikov, Riga Polytechnical Institute]

[Abstract] A general variational form is suggested for simplified statement of problems involving calculation of the compression and bending of thinwall rubber-metallic elastic elements based on the principle of the minimum additional work. The analysis is conducted using a problem typical for calculation of the stress state and loading diagrams of such elastic elements, the problem of compression and bending of an individual elastomer layer in an element. A simplified three-dimensional statement of the problem is achieved by accepting certain known hypotheses concerning the nature of the stress state in the thin elastomer layer, allowing the use of the principle of minimum additional work to be quite fruitful. Figures 2, references 17: Russian.

UDC 533.222

Attenuation of Pressure Wave in Granulated Bulk Polyethylene
18610150 Novosibirsk IZVESTIYA SIBIRSKOGO OTDELENIYA AKADEMII NAUK SSSR: SERIYA TEKHNICHESKIYE NAUKI in Russian No 15 Issue 4, Aug 88 (manuscript received 2 Feb 88) pp 61-63

[Article by A. F. Vakhgelt, Tomsk State University imeni V. V. Kuybyshev]

[Abstract] Propagation of a low-intensity pressure wave in loose bulk granulated polyethylene is studied to determine the nature of propagation of pressure waves in such materials. The evolution of the wave profile is computed, starting with an initial triangular profile. As the wave passes through the bulk polyethylene, it is gradually attenuated and the wave profile changes due to the nonlinear properties of the medium. A curve illustrates the attenuation of the wave with distance traveled indicating that the low-intensity wave is attenuated at a very short distance. Figures 2, references 3: Russian.

Forecasting S&T Progress in Machine Building Industry

Kiev VISNYK AKADEMIYI NAUK UKRAYINSKOYI RSR in Ukrainian No 1, Jan 89 pp 67-73

[Article by Academician, AN URSR [UkSSR Academy of Sciences], N.V. Novikov, Doctors of Economic Sciences I.S. Bem and B.I. Ginzburg and Candidate of Economic Sciences M.G. Dobrov under the "Economic Problems of the 12th Five-Year Plan" rubric; first paragraph is VISNYK AKADEMIYI NAUK UKRAYINSKOYI RSR abstract]

[Text] The article deals with the importance of long-term forecasting research aimed at the development of the machine building industry, and on the effect a scientific forecast has on parameters of products in this sector of the UkSSR national economy.

Improving the scientific substantiation and strenghtening the practical orientation of long-term integrated programs of S&T progress of individual industries, regions and the country as a whole is the most important direction of restructuring the system of State planning.

The Integrated Program of S&T Progress plays an important role in management of the national economy. In essence this is the main scientific preplanning document, on the basis of which main directions of the economic and social development of the USSR and individual Republics and Five-Year Plans for the national economy and individual industries are formed and long-term specific-purpose S&T programs are developed. Decisions of the 27th CPSU Congress emphasize the need to accomplish the "... transition to comprehensive planning of S&T progress and implement necessary measures so that plan targets are based on the achievements of S&T progress and ensure each industry's development based on wide implementation of new technology" [1, p 396].

One of the central sections of the Integrated Program is the long-term forecast of S&T progress in the machine building industry. In order to prepare this forecast, a Problem Commission "S&T Progress in Machine Building Industry" has been created within the framework of the Interagency Scientific Council on Problems of S&T and Social and Economic Forecasting under the auspices of the AN USSR Presidium and UkSSR Gosplan. The Commission performs organizational and scientific-methodological management of forecasting research in the machine building industry conducted in the Republic. The head organization of the Problem Commission is the Superhard Materials Institute, AN UkSSR. All in all over 80 Academy and branch scientific research institutes, design bureaus, VUZs and large industrial enterprises participate in this work.

One of the main goals of the Problem Commission is to develop organizational and methodological support of forecasting research. The objective of this work is to create a continuous forecasting system that would provide integrated and comprehensive analysis of the current status, trends and long-term prospects of the development of Republic's machine building industry. Main attention is paid to the analysis of possible alternatives of forecasted development and integrated assessment of their effect on end results of industry's activity; assessment of the correspondence between available resources and S&T targets set for solving during the forecasted period, and determination of the necessary resource support of priority directions of S&T progress (STP); and development of interbranch problems closely related to subject problems in other sections of the Integrated Program.

The adopted organizational and methodological support envisages the conducting of forecasting research in stages. We shall now examine the main stages of forecast preparation.

After receiving a request for developing a forecast, a working group of the Problem Commission analyzes the current status of Republic's machine building complex, defines main socioeconomic goals for its development and prepares a preliminary version of the forecast. This document contains a list of priority STP directions ranked according to the degree of urgency and end national economic effectiveness. On its basis, one develops two versions of the forecast that are extreme in their meaning: the initial (based on the assumption that the development of the machine building industry will basically proceed while preserving the trends formed in previous years) and the maximum possible (based on the assumption of as full as possible utilization of all newest S&T achievements).

At the same time, one performs integrated evaluation of propositions in the initial and maximum possible forecasts, compares them to resource capabilities, and determines ways for concentrating the S&T potential on solving high-priority problems. Based on this analysis, a program version of the forecast is developed. It characterizes a practically achievable level of S&T development of the machine building industry and is recommended for incorporation into the Integrated Program. The program version provides for reviewing the priorities in solving S&T problems, appropriation and redistribution of the required set of resources according to these priorities, and radical changes in the organization of production and management.

The final version of the forecast must determine priority directions of STP and formulate the requirements to the development of science and technology that, when met, will make it possible to ensure accelerated achievement by Republic's machine building industry of the world forefront in labor productivity and product quality.

Based on the above materials, a comprehensive concept of long-term S&T development of the machine building complex is formulated, and the level of parameters that

must be achieved by Republic's machine building industry (broken down to five-year intervals within the forecast period) is determined. Possible ways of accelerating S&T progress in individual industries and subindustries in order to achieve the forecast level of development are delineated. The long-term concept of STP in the machine building industry the forecast is based on reflects specific features of the development of individual industries; it also takes into account limitations on the use of various types of resources, which actually exist in certain regions of the Republic.

In preparing the final version of the forecast special attention is paid to the development of interbranch problems. At this stage, demands of the machine building industry to other branches of the national economy are formulated, and the effect of the forecasted development on improving the technical and economic level of production at enterprises-customers of the machine building industry products is assessed.

Despite positive changes in the development of the machine building complex that have begun to show up in recent years, industry's status does not yet meet the growing demands and goals.

Among the positive trends is the fact that Republic's machine building industry has been continuously developing at a faster pace than other industries. In 1971-1985 production volume of the machine building industry increased by a factor of more than 3.5. And in recent years over 80% of the increase in the production volume was achieved due to intensive factors, and first of all higher labor productivity. During the same period fixed production assets increased by a factor of 3.6, and capital assets per worker increased by a factor of more than 2.5. As a result of these changes, the machine building industry has become a main sector of Republic's national economy. It manufactures almost one-third of all industrial products in the UkSSR. And one can see a stable trend toward the reduction of unit parameters of material content of products (by more than 11% during this period) and increase in labor productivity (by a factor of 2.4) [2, p 49].

However, the current technical level and efficiency of the machine building industry are not sufficient for successfully solving problems facing the national economy. To a large degree this is due to the fact that recently a number of negative trends in industrial development have formed. Particularly, the rate of increase of production volume has slowed down: the increase in labor productivity is lagging the increase in the amount of capital assets per worker, which has resulted in lower capital productivity; capital investment had been aimed mainly at construction of new enterprises rather than retooling and reconstruction.

Special alarm is caused by substantial (and, as far as certain parameters are concerned, increasing) lag between technical, economic and performance characteristics of newly developed machines, instruments and equipment, on one hand, and those of their foreign analogs, on the other. Beginning in 1980, another negative trend is being observed—in terms of money, production volume of the machine building industry is rapidly increasing, while in terms of pieces of equipment it is decreasing, which leads to reduced effectiveness of measures aimed at retooling of the national economy [3, pp 4-5].

Accelerated modernization and technical and technological retooling of the machine building industry is the determining condition for bringing the development of country's production forces to qualitatively new frontiers. This problem will be solved along two directions—complete replacing physically and morally obsolete equipment in the next 7 to 10 years and ensuring efficient utilization of the renewed economic potential. The urgency of this approach is demonstrated by the fact that in recent decades the pace of wear of machines and equipment in the machine building complex has increased by 50 to 60%. This has led to the doubling of expenditures for their repair. And every fourth machine is in need of immediate replacement, due to its physical and moral obsolescence, while approximately half of the equipment fleet is in need of radical modernization, because it does not provide the necessary level of productivity, precision, resource consumption etc. [4, p 21].

One of the main reasons of the fact that most types of machine building products do not meet world standards is their low S&T level and low practical payback of research and development. Thus, for instance, during the 11th Five-Year Plan only approximately 11% of works conducted by the machine building industry NII [scientific research institutes] and KB [design bureaus] located in the Republic were aimed at achieving higher results compared to the best domestic and foreign analogs. And the majority of organizations had not been conducting developments of this class at all, while almost one-fourth of scientific institutions had not been awarded a single Certificate of Authorship [2, p 50].

President of the UkSSR Academy of Sciences Academician B.Ye. Paton emphasizes that further strengthening of the development of basic research in order to achieve world-level results is the basis for restructuring Academy's activity [8, p 13].

The payback of the VUZ sector of science remains extremely low, although the majority of researchers with the highest qualifications are concentrated there.

Analysis of data related to a number of new types of equipment that are being mastered at Ukrainian enterprises has demonstrated that as a rule they are not aimed at achieving the highest world level. The reason for this is that at the initial development stages the technical level is assessed based not on the forecasted world level but rather on foreign products that are in series production at the time. Thus the foundation for the lag of the S&T level and low competitiveness of domestic products

is already laid at the design stage. The existing practice of financing scientific organizations (rather than results of their activities) does not encourage the overcoming of the above mentioned drawbacks and leads to dispersion of scientists' effort among small problems, which hinders the solution of integrated problems, especially those that have interbranch character.

The need to radically improve the level of the domestic machine building industry urgently calls for the creation of a mechanism for managing S&T progress in this sphere of the national economy, which would be adequate to current conditions. This mechanism must be based on the concept of purposeful management of S&T progress. The essence of this concept is forming priority directions of the development of science and technology for a remote perspective and ensuring that the available potential, resources and capabilities match specific S&T goals stemming from these directions.

It is extremely important to use the unified system of evaluating the priority of various directions of S&T progress that reflects the specific character of the role and place of individual industries in solving common goals of developing country's national economic complex. And the system of evaluation criteria can and must change as time goes, in accordance with changes in objectives and goals facing individual industries.

Thus, for instance, when developing the forecast of the development of the machine building industry in the UkSSR, one was using a system of criteria for evaluating proposed S&T solutions that was proceeding from the general trend in industry's development. This trend consists in reorienting the effort from improving existing technologies and partial modernization of currently manufactured machines to developing new in principle comprehensive technological systems and machine complexes that substantially increase labor productivity, production efficiency and product quality. And promising S&T solutions must be based on the latest achievements of basic science, ensure outpacing development of key sectors of the national economy and facilitate their higher scientific content.

Based on the above, one could formulate the complex of criteria for evaluating the priority of research and development in the machine building industry as follows. Nowadays especially promising are works aimed at solving problems of radical technical and technological retooling of production and developing machines and equipment that ensure:

- high functional and economic efficiency manifested in substantially higher productivity, reliability and quality parameters (mainly providing a severalfold rather than a several percent increase);

- low operativeness and continuity of production, which indicate a high degree of saturation of the new technological system with automated hardware (robotic systems, rotary and rotary-conveyor complexes, flexible manufacturing systems etc.) and the possibility of creating an integral end product or enlarged functional modules;

- high efficiency of utilization of material and technical resources, demonstrated in higher wastelessness of production, replacement of certain types of raw and production materials with less scarce ones, and reduction of resource consumption per unit of useful effect;

- new product's resistance to moral obsolescence, demonstrated in its capability to ensure high parameters of enterprise's activity for a long time and reach the highest world level in the corresponding branch of technology;

- the capability of a new product to expand its sphere of application, reduce harmful environmental effects and in the long run increase nature's capacity for self-renewal; increased reliability and quality level of products made with the help of the new product; and

- the possibility to solve important social problems (increase the level of production safety, reduce the share of manual labor etc.).

An important condition for promising technological innovations (as a rule, technological systems and machine complexes) to meet the above criteria is their development in the form of three mutually complementing components:

- the technological-process component (principles of, methods for and the order of execution of technological operations, technical rules, regulations etc.);

- the hardware component (machine tool fleet, instrumentation, computer facilities etc.); and

- the organizational and managerial component (organizational and structural arrangements, management procedures, economic and normativeacts, standards etc.).

Correspondence of individual components of an innovation to each other and to specific features of the industry it will be implemented in is the determining condition for its highly effective performance. Analysis of a number of advanced S&T solutions has demonstrated that individual implementation of just one or two of the above components of S&T innovations does not make it possible to achieve a high end effectiveness of their production application [5, p 23]. And the effect of the implementation of a technological system is five to eight, and sometimes 15 to 20 times higher than that of individually created equipment and technological processes.

According to forecasting research that has been conducted, the general line in the long-term development of Republic's machine building industry up to the year 2010 is to achieve a technological "breakthrough" at key directions of S&T progress and reach the world-highest frontiers in labor productivity and product quality. Special attention will be paid to those directions in the development of the machine building industry where Republic's scientific and production potential is traditionally the most ponderable, including:

- development and application of promising technological processes, such as welding, powder metallurgy, wear-resistant coatings, application of lasers, development of flexible manufacturing systems and rotary and rotary-conveyor lines, implementation of robotics and CNC machine tools etc.;

- development of new structural and tool materials, including development of technologies for their manufacturing and application;

- manufacturing of new high-efficiency machines and equipment, such as turbines, coal miners, wheel excavators, diesel locomotives, metallurgical equipment, electrical machines, computer equipment and devices, tractors, corn and beet harvesters, plows, machines for animal husbandry and fodder production, trucks and cars, buses, railcars, equipment for the light and food industries etc.

During the forecasted period, Republic's machine building complex will be simultaneously solving two interrelated problems—modernizing the machine building industry itself and providing the national economy with equipment necessary to retool other industries. Based on available resources and existing priorities, it is expected that the first goal will be met in 1995-2000 and the second one by 2000-2005. Later, the development of the machine building industry will be aimed at consolidating its leading position in the world in main types of production and ensuring a timely practical response to the newest achievements of S&T progress. As a result of the implementation of scientific technical and organizational economic measures envisaged in the forecast, the UkSSR machine building complex will undergo a number of radical changes by 2010 and will become the most dynamically developing sector of the national economy [6, pp 92-93].

All in all, the qualitatively new status of Republic's machine building industry will be characterized by increased production volumes. The existing specialization of the machine building complex will deepen and broaden due to the creation (mainly on the basis of existing manufacturing systems) of new in principle manufacturing systems, which will be characterized by high scientific content. Republic's machine building industry will aim at the manufacturing of technological systems and machine complexes that will be fully at par with the best foreign analogs as far as their technical, economical and performance characteristics are concerned, while the key types of products will exceed the world S&T level. The rate of renewal of the mix of manufactured products will increase sharply.

By the end of the 12th Five-Year Plan 80 to 95% of manufactured machines and equipment will meet the advanced world S&T level. Annual renewal of products will be equal to 13% (which will make it possible to ensure an 8 to 10% rate of replacement of obsolete equipment); the share of microprocessor-equipped machines and machine tools will reach 30-32%, and the level of automation of design work and technological preparation of production will reach 23-40% [7].

Technical and technological retooling of the machine building industry will ensure a consistently high rate of increase in labor productivity. This will ensure integrated mechanization and automation of production, which will make it possible to reduce the share of manual labor severalfold.

Resource content of the machine building industry will change drastically. This will make it possible during the forecasted period to reach the level of such developed countries as Japan, FRG [the Federal Republic of Germany] and the USA, as far as effective resource consumption is concerned.

Beginning in 1990, practically all research and development in the machine building field conducted in the Republic will be aimed at achieving results that are at par with the best foreign achievements (and on priority directions of STP and in the majority of fields of UkSSR's S&T specialization - at exceeding the world level). The time necessary for the development and mastering of new technology will get substantially shorter, while the efficiency of scientific research and design planning work will increase. Accelerated production implementation of S&T achievements will make it possible for the machine building industry to rapidly respond to customers' requests and fully meet the national economic demand for new in principle advanced technology.

During the forecasted period, priority directions of work aimed at the improvement of the organizational economic mechanism of management of S&T progress in Republic's machine building industry will be as follows: deepening the economic independence of enterprises, including self-financing, self-repayment and self-management; shifting the investment policy to directing the funds to retooling and reconstruction; development of production specialization and cooperation, including creation of highly automated regional production facilities for manufacturing of general-purpose machine

building products; increasing the effectiveness of utilization of the accumulated scientific and manufacturing potential by concentrating available resources at key directions of S&T progress and accelerated implementation of all available capacity; developing standardization and metrological support; deepening international S&T cooperation, especially within the framework of the Integrated Program of STP of CEMA member countries, where necessary preconditions for organizing joint work according to a closed cycle "Research - Production" already exist.

The export capabilities of Republic's machine building industry will expand substantially. This will make it possible, first of all, to change the direction of foreign trade from exporting raw and production materials to shipping science-intensive products (technological systems and machine complexes) that are highly competitive in world markets. Second of all, it will make it possible to reduce national economic demand for importation of such machines and equipment.

Special attention will be paid to meeting stringent requirements to environmental protection. The forecasted development of Republic's machine building industry stipulates the need for a complex of measures aimed during the first stage at stabilizing the existing ecological situation, and in the long run at improving environment's capacity for self-renewal.

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Study of Accuracy of Motion of Industrial Robot Gripper in Space

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[Article by A. Sh. Koliskor and Ye. A. Pravotorova, Moscow]

[Text] The possibility of using industrial robots with contour control systems to execute one or another technological operation (welding, painting, assembly and so on) is largely determined by the accuracy of reproducing the movements of the links of the robot arm, and specifically, by grasping in given trajectories. Therefore, development of methods and means of study and checking the functional accuracy of robots at individual phases of their manufacture and under operating conditions is especially timely.

Development of these methods is complicated by the need for automatic measurement of the point coordinates of the robot links not only in statics, but during their movement in space as well. These types of metrological problems have not been fully developed with respect to machine-building conditions. The multilink nature, wide variety and complexity of the kinematic structures of robots, the wide nomenclature of technological operations, for fulfillment of which they are designed, also complicate the problem of working out methods of evaluating the accuracy of functioning of different robots.

Universal, general and complete information for solution of many problems of the technical diagnostics of industrial robots may be the laws of motion of their links as solids in space.

A method of determining the actual laws of motion of robot links, for example, of grasping in space, is developed in this paper on the basis of l-coordinates[1] using computer modeling. Measurement of the l-coordinates of a body in space, as is required in the problem of determining the functional accuracy of a robot, is a simpler problem compared to that of using classical coordinate systems[2], since very simple devices can be solved due to the identical linear dimensions of all six coordinates that characterize the position of a body in l-coordinates. The position of a solid in a space with respect to some coordinate system is determined by six numbers. The lengths l_1, l_2, ..., l_6 of six segments that connect the body to a fixed base such that a geometrically fixed structure is formed at given values of l_1, l_2,,

..., l_6 is used as these numbers in the l-coordinate system[1]. The equations of motion of a free solid in l-coordinates have the form

$$l_1=f_1(t),\quad l_2=f_2(t),\quad l_3=f_3(t),\quad l_4=f_4(t),\quad l_5=f_5(t),\quad l_6=f_6(t), \tag{1}$$

where t is current time.

Analysis of the structures of l-coordinates permitted us to distinguish a number of structures in which the coordinates of arbitrary point R of the robot gripper can be found analytically and are obtained in explicit form. One of these structures is presented in Figure 1. Its characteristic feature is that three points of base 1 (A, B, C), not lying on the same straight line, are joined by six segments, equal to the l-coordinates, with three points of body 2 (a, b, c), not lying on the same straight line; moreover, three segments converge at one point of the base, two converge at another point, and one converges at a third point. In the given structure, segments corresponding to the l-coordinates and segments that join the points of the base to each other and also segments that join the points of the body to each other form three tetrahedrons aABC, baBC and cabC. Geometric consideration of the sequence of the indicated tetrahedrons permits one to determine sequentially the coordinates of points a, b and c in system Oxyz, assuming that the coordinates of points $A(x_A, y_A, z_A)$, $B(x_B, y_B, z_B)$, and $C(x_C, y_C, z_C)$ are given in fixed coordinate system Oxyz, bound to the base, coordinates $a(x'_a, y'_a, m'_a)$, $b(x'_b, y'_b, z'_b)$, and $c(x'_c, y'_c, z'_c)$ in coordinate system O'x'y'z', bound to the body, and l-coordinates l_1, l_2, ..., l_6 are given. The tetrahedron Rabc is considered to determine some point R of a body whose position is given in system O'x'y'z' in coordinate system Oxyz. The result of sequential solutions of several systems of equations, related to consideration of the indicated series of tetrahedrons, will be the values of coordinates x, y, z of arbitrary R of the robot gripper, dependent on the values of l_1, l_2, ..., l_6

$$\begin{aligned} x&=x(l_1, l_2, \ldots, l_6),\\ y&=y(l_1, l_2, \ldots, l_6),\\ z&=z(l_1, l_2, \ldots, l_6), \end{aligned} \tag{2}$$

where l_1, l_2, ..., l_6 are time functions, given according to relations (1).

Equations (2) correspond to the ideal of motion of the gripper. Under real conditions, the laws of motion of the gripper will be reproduced with deviations, coordinates l_1, l_2, ..., l_6 will assume the value of $l_1 + \Delta l_1$, $l_2 + \Delta l_2$, ..., $l_6 + \Delta l_6$, respectively, at each moment of time, while the equations of motion of point R assume the form

$$x^*=x(l_1+\Delta l_1, l_2+\Delta l_2, \ldots, l_6+\Delta l_6),\quad y^*=y(l_1+\Delta l_1, l_2+\Delta l_2, \ldots, l_6+\Delta l_6),$$
$$z^*=z(l_1+\Delta l_1, l_2+\Delta l_2, \ldots, l_6+\Delta l_6). \tag{3}$$

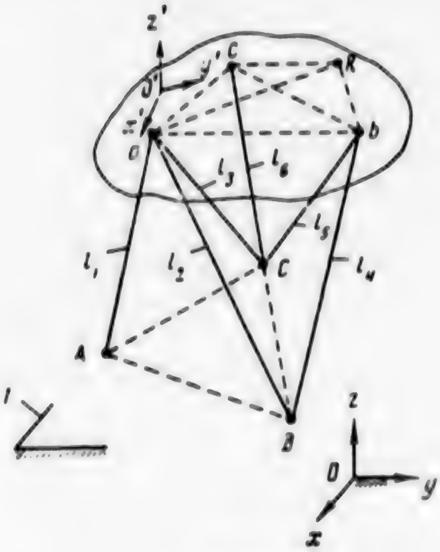

Figure 1

The problem is to estimate the corresponding deviations of the real trajectory of point R from the ideal point

$$\begin{aligned} \Delta x&=x^*-x=x(l_1+\Delta l_1, l_2+\Delta l_2, \ldots, l_6+\Delta l_6)-x(l_1, l_2, \ldots, l_6),\\ \Delta y&=y^*-y=y(l_1+\Delta l_1, l_2+\Delta l_2, \ldots, l_6+\Delta l_6)-y(l_1, l_2, \ldots, l_6),\\ \Delta z&=z^*-z=z(l_1+\Delta l_1, l_2+\Delta l_2, \ldots, l_6+\Delta l_6)-z(l_1, l_2, \ldots, l_6). \end{aligned} \tag{4}$$

The principal complexity of obtaining the information in the form of laws of (1) or of their analogues includes the development of the corresponding devices for recording the six laws of motion.

The method proposed below for determining the laws of motion is directed toward fundamental simplification of devices for recording the laws of motion. It utilizes the property of robots that they are related to cyclic machines. The actuating members of industrial robots perform a motion, as a result of which they arrive at the same position in which they were at the beginning of the motion. Thus, the actuating member, for example, the gripper, performs a cyclic motion. The given (nominal) laws of motion remain the same until the functional program of the robot changes.

This characteristic of robots permits one[1] to obtain information about the laws of motion of the points of the links and of the links themselves by simultaneous measurement and recording of individual laws that form the aggregate of equations (1). Only part of the aggregate of laws (for example, one of six) is recorded during each cycle of motion, while all the laws of motion of the given aggregate are recorded sequentially during different cycles of motion. The given approach is applicable to acyclic mechanisms and machines, if cyclic motion for research purposes can be organized in them.

The use of the method of alternate recording of individual laws of motion permits fundamental simplification of the means of obtaining information about the laws of motion and simplification of the recording part of the device, since its memory capacity may be reduced, and permits one to relieve the arrangement of the measuring device in the working zone of the robot.

If the motion of the link is considered as a determinant process, it is sufficient in the resulting cycles of motion to measure and record each of the laws of the aggregate once. If the motion of the link is considered as a random process,[2, 3] then simultaneous recording of individual laws of the aggregate impose its specifics, which leads to the use of simulation probability modeling. With multiple reproduction of the cycles of motion of the robot gripper, deviations of the linear coordinates are a random vector at each moment of time. Therefore, relations (3), which describe the motion of the robot gripper, are random functions, while the mathematical model of the functioning of the robot from the viewpoint of evaluating its accuracy is described by a system of stochastic equations (4).

It is difficult to study these models by analytical methods in view of the complexity of the functional dependence that links the stochastic inputs and outputs and due to the multiplicity of the vector of random deviations of the 1-coordinates (the dimension is equal to six), the components of which in the general case are correction-related. Moreover, it should be noted that analytical solution is essentially possible only provided that the laws of distribution of the random values are expressed analytically. Imposing restrictions, inevitable in many cases, and simplification of the mathematical model result in impermissible errors of the results of research and calculations.

The simulation modeling methods used at present provide a solution of the considered problems without imposition of any restrictions on the nature of distribution of the random values, and also on the type of statistical objects of study of accuracy, which can be represented as random mutually independent values, as well as random vectors with different closeness of the correlation between its components.

Let us turn to study of the functional accuracy of a robot for the case when deviations of 1-coordinates are mutually independent random values. The possibility of replacing simultaneous recording of six errors $\Delta 1_1$, $\Delta 1_2$, ..., $\Delta 1_6$ in the same operating cycle of the robot by alternate recording of them in sequential cycles is obvious. Multiple measurements of each of the indicated errors are made separately for this, and their laws of distribution are then determined and the errors are convoluted by probability modeling according to equations of type (2)-(4), after which the errors of the position of the robot along axes x, y, z are computed. This procedure is repeated N times. The values of the simulated errors are formulated by random number sensors according to the derived distribution laws. As a result, we find the distribution laws and their numerical characteristics for values of Δx, Δy and Δz.

The distribution laws are presented in Figure 2 in the form of polygons for output errors Δx(a), Δy(b), and Δz(c), where the errors are plotted along the x axis, while the normalized details, which are the ratios of the number of n values of errors, which fall into each of the aggregate of partitioning intervals, to the value of width h_{111} of the partitioning interval. The numerical characteristics of these laws—the mean value X and the mean square deviation S—assume the following values: X bar = -0.222, S = 0.314, (for error Δx), X bar = 0016, S = 0.365 (for error Δy), and X bar = 0.001, S = 0.27 (for error Δz). It was assumed during simulation that errors of 1-coordinates are subject to normal laws with mean value equal to zero. The mean square deviations of the errors assumed a value $\sigma(\Delta 1_i) = 0.04$ mm (i = 1, 2, ..., 6). In this case,

$$x_A = 150 \text{ мм},\ y_A = 150 \text{ мм},\ z_A = 150 \text{ мм},\ x_B = 300 \text{ мм},\ y_B = 300 \text{ мм};\ z_B = 300 \text{ мм},\ x_C = 100 \text{ мм},\ y_C = 100 \text{ мм},\ z_C = 100 \text{ мм},\ x_a' = 30 \text{ мм},\ y_a' = 0,\ z_a' = 0,\ x_b' = 0,\ y_b' = 51{,}96 \text{ мм},\ z_b' = 0,\ x_c' = 30 \text{ мм},\ y_c' = 0,\ z_c' = 0,\ x' = 0,\ y' = 17{,}32 \text{ мм},\ z' = 197 \text{ мм},\ l_1, l_2, \ldots,\ l_6 = 1000 \text{ мм}.$$

The effectiveness of simulation modeling methods is manifested especially when studying the functional accuracy of robots in the presence of a correlation relation between the errors of the 1-coordinates. Replacement of simultaneous measurement of six 1-coordinates in one cycle by six alternate measurements of these coordinates in six sequential cycles is incompetent in this case without sufficient substantiations. Statistical experiment were conducted on the computer, which correspond to the two measurement models.

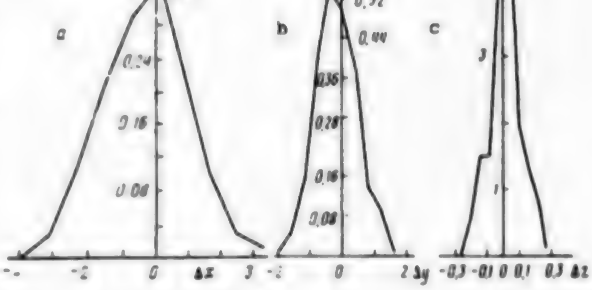

Figure 2

An experiment, corresponding to the first model, envisioned simulation of six errors of the l-coordinates, measured simultaneously, on the basis of their given distribution laws and of the correlation matrix, which links these errors.

$$K=\begin{vmatrix} k_{11} & k_{12} & \dots & k_{16} \\ k_{21} & k_{22} & \dots & k_{26} \\ \dots & \dots & \dots & \dots \\ k_{61} & k_{62} & \dots & k_{66} \end{vmatrix}, \qquad (5)$$

where $k_{ij} = k_{ji}$, $k_{ij} = \rho_{ij}\sigma_i\sigma_j$, σ_i is the variants of the i-th error of generalized coordinates (i - 1, 2, ..., 6) and ρ_{ij} is the correlation coefficient between the i-th and j-th errors.

The derived values of the components of the error vectors are inserted in formulas that determine the errors of position of the point of the robot gripper. As a result of simulation of measurements of errors of the generalized coordinates of a robot in volume N_1*, a representative aggregate of errors Δx, Δy, Δz is found. Statistical processing of this aggregate permits one to find the numerical characteristics of their distribution laws and of the distribution laws themselves in the form of histograms or of distribution polygons.

An experiment corresponding to the second model envisioned simulation of alternate recording of the errors of the l-coordinates in sequential cycles. A six-dimensional vector (curly brace) $\Delta l_1, \Delta l_2, ..., \Delta l_6$ (end curly brace) is also simulated in this case, but in a considerably different manner. The first realization of the random vector (curly brace) $\Delta l_1^{(1)}, \Delta l_2^{(1)}, ..., \Delta l_6^{(1)}$ (end curly brace) is initially determined according to the correlation matrix (5) and according to the given distribution laws and only one component of this vector $\Delta l_1^{(1)}$is taken, which corresponds to recording only one error Δl_1 during the first cycle of motion of the robot gripper. The second realization of error vector (curly brace) $\Delta l_1^{(2)}, \Delta l_2^{(2)}, ..., \Delta l_6^{(2)}$ is then simulated and its second component $\Delta l_2^{(2)}$ is taken, which corresponds to recording the second error Δl_2 during the second cycle of motion of the robot gripper and so on. Thus, to find a single realization of the vector of errors of l-coordinates whose values are subject to subsequent transformations, one must simulate six vectors. This corresponds to completing six functional cycles of the robot and of alternate recording of only one error of the l-coordinate during each cycle. The error vector, consisting of six simulations of the vector, is inserted into the corresponding formulas for determination of errors Δx, Δy, Δz. It can be written in the following form: (curly brace) $\Delta l_1^{(1)}, \Delta l_2^{(2)}, \Delta l_3^{(3)}, \Delta l_4^{(4)}, \Delta l_5^{(5)}, \Delta l_6^{(6)}$ (end curly brace). Thus, multiple simulation with realization of $N_2^* = 6N_1^*$ must be performed to obtain the statistical aggregate of errors of the functional accuracy of the robot in the same volume as in the first experiment. Comparison of the results of two experiments, corresponding to these model, permitted us to conclude that alternate registration of the generalized coordinates is possible during sequential operating cycles of the robot. The probability density of the normal vector of the error of generalized coordinates

$$\eta=\{\Delta l_1, \Delta l_2, \dots, \Delta l_6\}: w_6(y_1, y_2, \dots$$
$$\dots, y_6)=(2\pi)^{-3}(\det K)^{1/2}\exp\{-1/2(y-a)^T K(y-a)\},$$

where column vectors y = (curly brace) $y_1, y_2, ..., y_6$ (end curly brace) and a = (curly brace) $a_1, a_2, ..., a_6$ (end curly brace) show the possible values and mean values, respectively, of components $\Delta l_1, \Delta l_2, ..., \Delta l_6$; $(y - a)^T$ is a row rector found by transposition of (y - a), K is correlation matrix (5), and det K is the determinant of correlation matrix K.

In the special case when a = O and correlation matrix K = L (where E is a unit matrix with elements k_{ij} = O, i not equal to j, k_{ij} = 1, i = 1, ..., 6) the components η_{io} of vector η will be (curly brace) $\Delta l_1, \Delta l_2, ..., \Delta l_6$ (end curley brace) independently normal distributed values with unit variance $\sigma_o^2 = 1$ and zero mean values, simulated by earlier developed methods[4,5]. Vector η can generally be formulated in the form η = Aη + a, where the transforming matrix A can be constructed by different methods.

The simplest method is that of constructing the transforming matrix A, given in the form

$$A=\begin{vmatrix} a_{11} & 0 & 0 & \dots & 0 \\ a_{21} & a_{22} & 0 & \dots & 0 \\ \dots & \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & a_{n3} & \dots & a_{nn} \end{vmatrix}.$$

The main idea of the outlined modeling method is that, having developed n independent normally distributed values $\xi_1, \xi_2, ..., \xi_n$ with zero mean values and unit variance, to subject them to linear transformation A, after which the derived values of $\eta_1, \eta_2, ..., \eta_n$ would have a preassigned matrix of second moments U = (curly brace)k_{ij} (end curly brace). We note that the property of normality is preserved upon liner transformations. Triangular matrix A translates values $\xi_1, \xi_2 ..., \xi_n$ to $\eta_1, \eta_2, ..., \eta_n$ with given correlation relations

$$\eta_1=a_{11}\xi_1, \quad \eta_2=a_{21}\xi_1+a_{22}\xi_2, \dots, \quad \eta_n=a_{n1}\xi_1+a_{n2}\xi_2 + \dots + a_{nn}\xi_n.$$

Let us find its elements a_{ij} from the condition $M\eta_i\eta_j = k_{ij}$. The coefficients a_{ij} were calculated on the basis of the recursion formula

$$a_{ij}=\left(k_{ij}-\sum_{r=1}^{j-1}a_{ir}a_{jr}\right)\Big/\sqrt{k_{ij}-\sum_{r=1}^{j-1}a_{jr}^{2}}.$$

$$\sum_{r=1}^{0}a_{ir}a_{jr}=0,1\leq j\leq i\leq n.$$

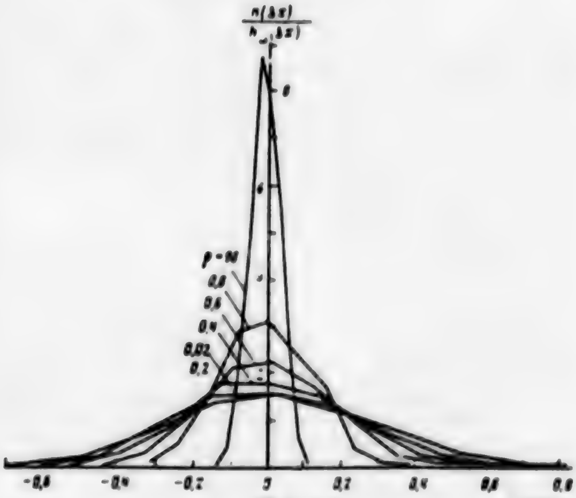

Figure 3

To determine the effect of the correlation function between the errors of generalized l-coordinates on the errors of the position of the given point of the robot gripper, six functions, which differ from each other by the values of the correlation coefficient equal to $\rho = 0.02$, 0.2, 0.4, 0.6, 0.8, and 0.98, were simulated. The first value of the correlation coefficient brought the postulated conditions close to the considered case of independent errors of the generalized coordinates. The last value

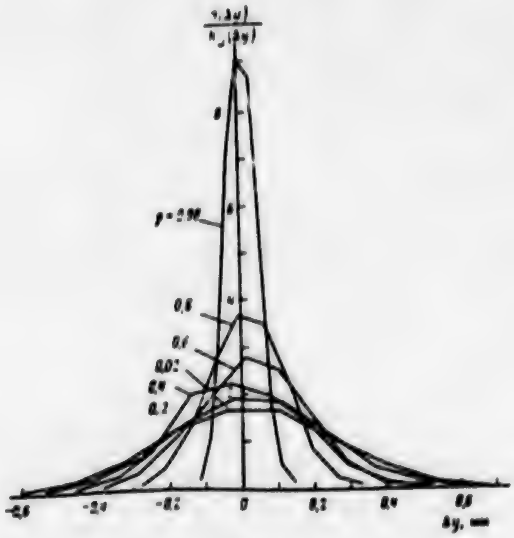

Figure 4

$\rho = 0.98$ brought the condition of the problem close to the presence of the functional dependence between errors. Thus, the aggregate of the adopted values of ρ rather adequately encompasses the range of possible degrees of closeness of the correlation relation between errors of the l-coordinates (Figure 3).

The random error vectors of the l-coordinates within one variant of input data had identical mean values and mean square deviations. Models of random vectors differed only by the degree of the correlation relation between the components of the vector. The values of the numerical parameters (of the mean values and mean square deviations) of the distribution laws of the point position errors of the robot gripper Δx, Δy, and Δz at different levels of the correlation relation between the errors of the generalized coordinates for the same variant of input data as the case of independent generalized l-coordinates, found as a result of modeling, are presented in the table.

	Error of Position							
	Δx				Δy			
Correlation Coefficient	Mean Value		Mean Square Deviation		Mean Value		Mean Square Deviation	
	I	II	I	II	I	II	I	II
0.02	-0.004	-0.011	0.317	0.307	0.026	0.023	0.361	0.350
0.20	-0.007	-0.007	0.287	0.309	0.026	0.024	0.326	0.351
0.40	-0.010	-0.006	0.249	0.312	0.022	0.028	0.283	0.352
0.60	-0.014	-0.007	0.206	0.312	0.020	0.031	0.230	0.354
0.80	-0.019	-0.009	0.147	0.312	0.017	0.032	0.163	0.353
0.98	-0.027	-0.013	0.054	0.309	0.012	0.030	0.055	0.352

Error of Position
Δz

Correlation Coefficient	Mean Value		Mean Square Deviation	
	I	II	I	II
0.02	0.001	0.001	0.029	0.028
0.20	0.001	0.001	0.031	0.028
0.40	0.001	0.001	0.033	0.028
0.60	0.000	0.001	0.035	0.028
0.80	-0.000	0.001	0.037	0.028
0.98	-0.001	0.001	0.038	0.028

Analysis of the resulting data permits one to reach the following main conclusions. As one should expect, the results of check simulation by two methods—upon simultaneous measurement of six 1-coordinates and upon their sequential measurement—for correlation coefficient $\rho = 0.02$ essentially coincide with each other and are similar to the results for the case of independent 1-coordinates.

Simulation of alternate recording of errors of the 1-coordinates within one variant of input data results in essentially identical results for all values of the correlation coefficient, which indicates that alternate recording of them may result in distortion of the estimate of the functional accuracy of the robot when the correlation significantly affects the results during simultaneous measurement of the generalized coordinates.

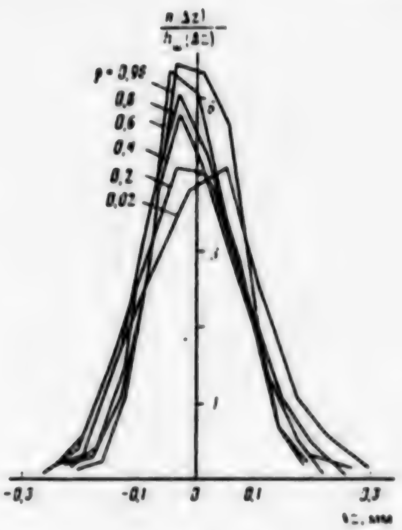

Figure 5

The errors due to replacement of simultaneous registration of the 1-coordinates by the aggregate of their alternate registrations in sequential cycles are sometimes negligible, at values of the correlation coefficient that did not exceed 0.4.

However, the situation changes at other input data. The distribution polygons of the output errors of Δx, Δy, and Δz, respectively, at different values of the correlation coefficient $l_1 = l_2 = ..., = l_6 = 400$ mm and at those values of the remaining parameters as before are presented in Figures 3-5. The position errors are obviously considerably dependent on the correlation coefficients and their mean square deviations differ from each other several fold as a function of ρ.

Thus, it is shown that the method of determining the actual laws of motion of the links (gripper) of a robot arm by alternate registration of these laws and by subsequent convolution of the measuring information by simulation probability modeling permits one to obtain complete information about motion both in the absence of a correlation relation between individual generalized coordinates and with this relation. In the latter case, it is required either to perform pair registration of the laws of motion or to provide the corresponding arrangement of the axes of the 1-coordinates on the link, selecting them from the resulting conditions of invariance of the registered coordinates to the correlation relation between them. Moreover, it was established that the correlation relation essentially has no influence on formulation of the laws of motion, found by convolution of the information at specific parameters of errors of the 1-coordinates and at the nominal values of these coordinates. This permits one to study the robot on the one cycle-one coordinate principle, which reduces the number of measuring and recording devices, facilitates arrangement of them in the working zone and, because of this, simplifies the study.

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Organization of State Acceptance Work at Production Association Chelyabinsk Tractor Plant imeni V. I. Lenin

18610181 Moscow STANDARTY I KACHESTVO in Russian No 10, Oct 88 pp 55-60

[Article by A. I. Dergunov, Director of State Acceptance, and N. A. Samokhvalov, Director of State Acceptance Group]

[Text] The year 1987 was one of establishing the collective and a year of finding ways and methods of work for State Acceptance at the Production Association Chelyabinsk Tractor Plant imeni V. I. Lenin. We proceeded from the fact that slow elimination of repeated production defects, the low level of executive discipline, development and introduction of easily fulfillable, but low, effective measures are typical for the activity of the association in improving the quality of manufactured tractors. The effective and efficient struggle with these negative phenomena required not only formation of a State Acceptance collective from principled and highly skilled specialists with initiative, but also the corresponding organization of their work. Therefore, the system of work on product quality that has become established in the association was first carefully and universally analyzed.

The results of analysis showed that the basis of this system are three types of production engineering activity (Figure 1):

Acquisition and processing of information on tractors under operating and test conditions;

Preparation of engineering and technical solutions, directed toward improving the failure-free nature and technical level of tractors;

Fulfillment of solutions and introduction of the developed measures.

The system operates in the following manner. Data on failures of vehicles are sent to the Administration of Product Operation (UEI). UEI analyzes the information and brings it to the manufacturers through the Administration of Technical Control (UTK): the high-power tractor plant (ZMT), motor plant (MZ), Chelyabinsk Tractor Transmission Plant (ChZTT) and Chelyabinsk Turbocompressor Plant (ChZT), Yemanchelinsk Mechanical Plant (YeMZ), tractor production (TP), tractor engine production (PTD), press-welding production (PSP), foundry (LP), forge production (KP) and Chelyabinsk Special Tools and Production Accessories Plant (ChZSTO). Information is sent to the main specialized design office for tractors (GSKB) with preliminary separation of passages for divergent and conditionally accepted claims. Accepted claims are related to specific guilty parties at a meeting of the permanently acting committee on quality (PDKK) by a joint decision of interested engineering services.

Specialists of the Department of Foreign Economic Ties (OVES) provide information about the operation of tractors abroad. The plant has information on trials of tractors at the head organizations for State trials (GOGI). Moreover, information about the quality of the vehicles is delivered from GSKB, which tests the tractors on stands and test tracks, and also from UTK and State Acceptance (GP), which have available data on tests of parts, assemblies, units and tractors on stands during their manufacture. Processing and classification, accumulation and distribution of all this information is completed by the Administration of Automated Systems (UAS).

The developed and adopted solutions and measures to improve the technical level and product quality are reflected in specific integrated scientific technical programs (sector and association), annual programs "Quality," and protocols of days of evaluation of quality (DOK), in decisions of the permanently acting committee on quality (PDKK), and in the current decisions of the chief engineer.

The Department of Check of Execution (OKI) on the program of the automated system for check of execution of jobs (ASKIZ) currently monitors the course of fulfillment of the developed measures at the association.

Having studied the system of work on quality at the association, we concluded that it is basically adequate to the problems faced by the enterprises and State Acceptance and has great potential possibilities. To realize these possibilities, it is necessary only to perfect and improve the system, by increasing the reliability of

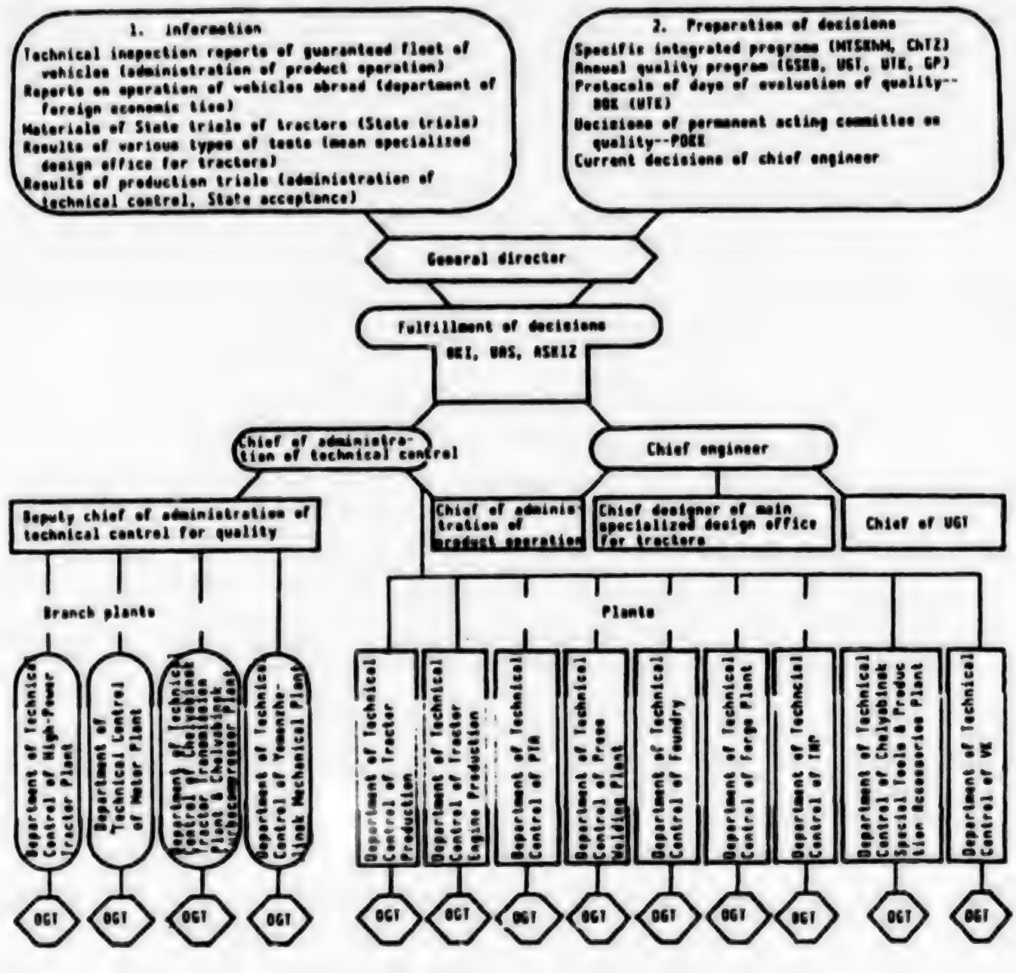

Figure 1. Organization of Work on Quality at PO Chelyabinsk Tractor Plant imeni V. I. Lenin

information, substantiation of adopted decisions and the currentness of their realization. This circumstance was taken into account to the maximum possible degree in determination of the structure, composition and numbers of State Acceptance (Figure 2).

There are 140 persons now working in State Acceptance, which comprises 5 percent of the staff of the UTK. There are 13 production and 3 specialized groups on the staff of State Acceptance. The production groups are divided into product acceptance sections and engineering work sections (UIR). The specialized groups (analysis, State inspection and metrologists) inform, coordinate and render methodical assistance to the engineering work sections of the production groups. This helps all groups and sections to arrange their work based on production design analysis of parts and assemblies to be manufactured.

One of the main goals of State Acceptance is to impart greater dynamism to the plant system of work on quality and due to this to improve the technical level and failure-free nature of tractors. The postulated problem can be solved only with the correct organizational and methodical approach, capable of discovering the causes of the main product defects and of directing the efforts of the plant and State Acceptance to correction of them, by thus providing a reduction of claim and repair-operating expenditures.

This approach is most fully realized by a group that performs State Acceptance of products at the tractor transmission and turbocompressor plants (ChZTT and ChZT). Analysis of information on failures of the guaranteed fleet of machines, performed by specialists of this group, showed (Figure 1) that every seventh communication about failures of tractors during operation in 1986 occurred due to product defects of ChZTT and ChZT. Moreover, the gearbox, turbocompressor, final reduction assembly and crankpin mechanisms were included in the group of the most defective tractor assemblies and, accordingly, improvement of their quality was the main direction of work to improve its failure-free nature. It should be noted that plant specialists knew beforehand

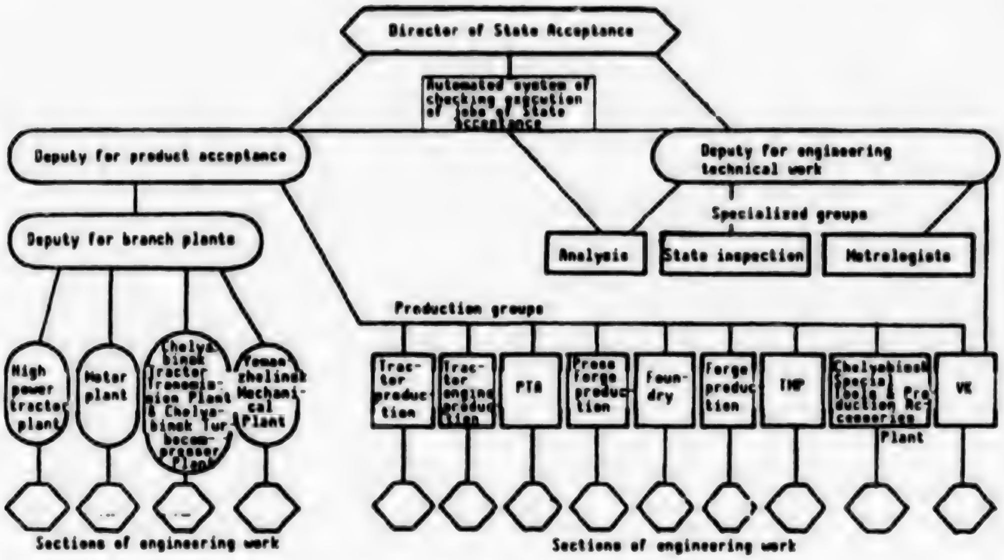

Figure 2. Block Diagram of State Acceptance

the causes of failure of individual parts and assemblies, but their actions to correct these causes were not coordinated and did not lead to the necessary results for years. Therefore, the workers of the State Acceptance group at ChZTT and ChZT first classified and analyzed the cause-effect mechanism of failures of gearboxes and turbocompressors (Figure 2).

As one can see from Figure 2, failures occurred in the gearbox due to failure of seven parts. The turbocompressor had four defective parts, one of which (seal ring) was purchased. A total of 66 percent of the total number of failures in the gearbox occurred due to breaks of the blade of the reverse fork and failure of bearings with disruption of the efficiency of the nut fastener. Increased wear of the bearing assembly yielded 48 percent of the total number of failures in the turbocompressor. In order for the GSKB and the corresponding suppliers to correct the causes of these defects, it was necessary to include the corresponding jobs in specific integrated programs, annual orders on quality and other distributed documents. However, this was possible in 1987 only through the joint efforts of the plant and State Acceptance.

In some cases, an assembly loses efficiency due to accumulation of errors in manufacture of the parts, assembled into a unit, rather thandue to failure of a part.

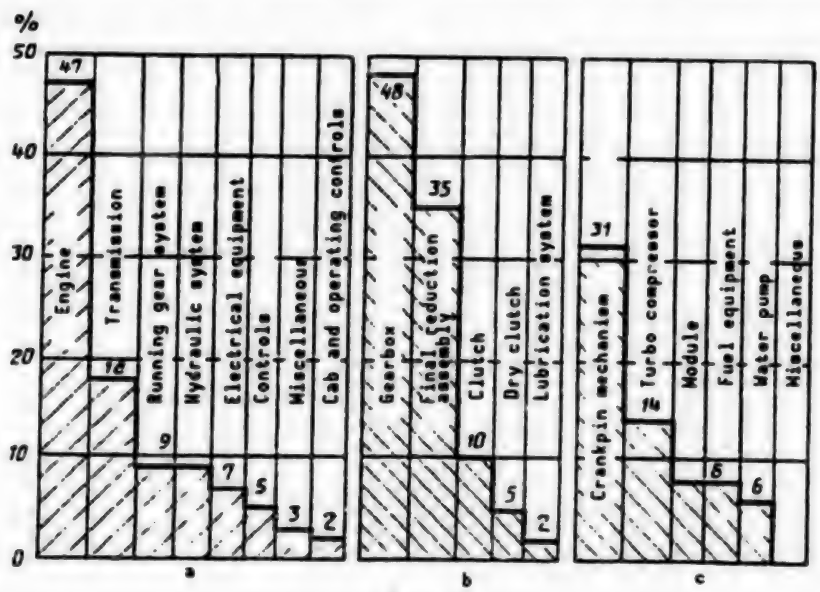

Figure 3.

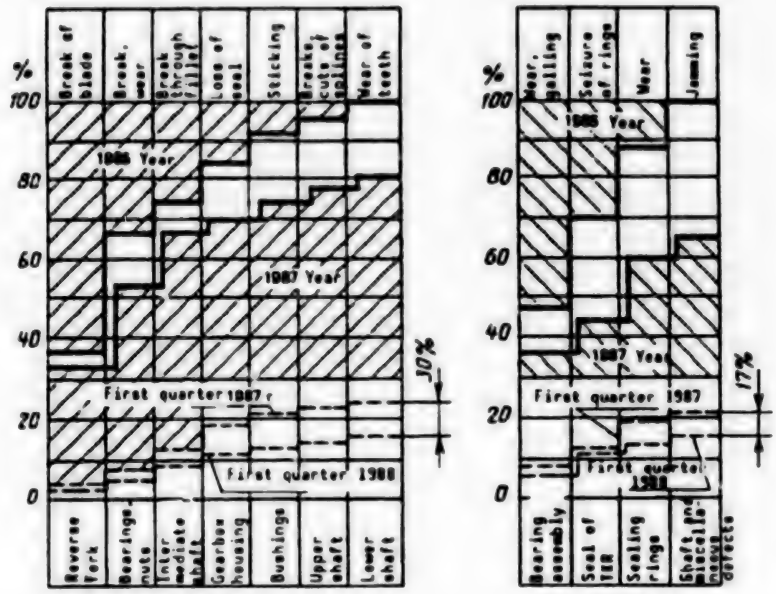

Figure 4

Where the technology of manufacture does not provide stable quality or where the requirements of technical documentation are unjustifiably overstated, there is a need to work according to a document that temporarily authorizes deviation from the drawing. The use of these documents at the plant has a negative effect on the quality of the manufactured product. The production section where the authorizing document is effective is justifiably considered a bottleneck.

The specialists of the group worked out charts of the status and assurance of quality of manufacture to exercise constant monitoring in production, especially of its bottlenecks (see table). The charts encompass all information about the process of manufacture of parts. Thus, the names and numbers of parts subject to check are enumerated in column 1. Information about the action and content of authorizing documents (RB), about conducting volatile checks (LK) of production with notations of the check periods is entered in column 2, filled in the form of a lenticular annual calendar. The specifications of the production drawing documentation, fulfillment of which is problematical, are indicated in column 3. The requirements of the normative and technical documentation for specific parts are noted in column 4.

The data presented in Figures 3 and 4 and also in the table were obtained through the use of information provided by the plant operating system on quality. Therefore, the rather high effect in the activity of State

Name and number of part	Year: I quarte	II quarter	III quarter	IV quarter	Parameters of quality	Requirements of normative and technical documentation
1	2				3	4
Assembly ship No 1 of Chelyabinsk Tractor Transmission Plant						
Housings	Section for manufacture of bearing housings					
18-12-187					0.12 A	GOST 3325-85; § 1.2
18-12-188					B	
18-12-189					0.05 B	
18-12-190	Essential control		Authorizing documents		A	
					0,1 A	

Table 1

Acceptance is provided by the innovation of analysis, which includes its specific nature in implementation of the principle—from failure to part, rather than of the information used. The simplicity and clarity of representation of the results of analysis permits very precise determination of the direction of joint efforts of the plant and State Acceptance in work to improve the technical level and quality of manufactured products.

Business-like relations of production workers, engineering services, department of technical control and State Acceptance were established at the ChZTT and ChZT plants due to correct postulation of organizational and methodical work on quality. Combinations of required and realistically fulfilled measures, directed toward direction of the main causes of failures of gearboxes and turbocompressors, which are being implemented successfully, were worked out on this basis. This ensures an increase of failure-free nature of the vehicles. Thus, one can conclude from Figure 3 that the number of communications from the operating points on failures of gearboxes was reduced by 20 percent compared to 1986 and by 30 percent compared to the first quarters of 1987 and 1988. These figures comprised 35 and 17 percent, respectively, for turbocompressors.

ChZTT and ChZT occupy the leading position in the association in work on

quality. The operating experience of State Acceptance at these plants is being used in all its subdivisions in the production association Chelyabinsk Tractor Plant imeni V. I. Lenin.

Renaming of Journal MASHINOVEDENIYE to PROBLEMY MASHINOSTROYENIYA I NADEZHNOSTI MASHIN

18610329a Moscow MASHINOVEDENIYE in Russian No 1, Jan-Feb 89 pp 3-4

[Text] Dear Comrades! In the interests of developing fundamental and applied research on scientific problems of machine building and the reliability of machines and database organization and support in these fields of science, the journal MASHINOVEDENIYE of the USSR Academy of Sciences will be renamed during 1989 to the journal PROBLEMY MASHINOSTROYENIYA I NADEZHNOSTI MASHIN.

The planned expansion of the topics of the journal will permit us to answer more completely the requests of machine building and to recruit a wide range of scientific workers, designers, technicians and other specialists, involved in development of the scientific fundamentals, development, modification, operation and repair of modern and future machines and their systems, and improvement of the methods of calculation and testing of machines.

The editorial board of the journal opens fo broad discussion the draft of the profile of the journal PROBLEMY MASHINOSTROYENIYA I NADEZHNOSTI MASHIN of the USSR Academy of Sciences, published below. The editorial board requests that you send your suggestions and comments to the address of the editors of the journal: 103717, GSP, Moscow, K-62, Podsosenskiy per., 21.

Journal PROBLEMY MASHINOSTROYENIYA I NADEZHNOSTI MASHIN AN SSSR (Draft of Journal Profile).

The journal PROBLEMY MASHINOSTROYENIYA I NADEZHNOSTI MASHIN has been created on the basis of renaming the journal MASHINOVEDENIYE for more complete database management and support and for formulation of a progressive ideology of development of fundamental and applied research on scientific problems of machine building and the reliability of machines.

The main topic of the journal encompasses the following directions: general problems of machine science and machine building, the reliability, strength, and wear resistance of machines and structures, the mechanics of machines, engineering electronics, control of machines, automation in machine building, essentially new progressive technologies in machine building, and experimental mechanics, diagnostics and testing.

General problems of machine science and machine building include principal problems of the development of the science of machines and machine building, and also timely scientific problems of scientific and technical progress in machine building.

The reliability, strength and wear resistance of machines and structures encompasses the theoretical and applied problems of the reliability and durability of machines, assemblies and parts of machines, structures and their elements, strength and wear resistance of new machine-building materials, including problems of study of low-cycle and multicycle fatigue, thermal stress, simulation of breakdown processes, wear, formation and development of cracks, forecasting of the service life of mechanisms, machines and structures, and also integrated problems of regulation of the operating conditions of machines according to reliability and durability criteria.

The mechanics of machines, engineering electronics, and control of machines includes modern concepts of analysis and design of mechanisms, machines and complexes of machines, precision theory, vibration theory, dynamics, vibration acoustics of machines, biomechanics, problems of mathematical modeling when conducting fundamental and applied research in the mechanics of machines, engineering electronics and control and machines.

Engineering electronics encompasses timely problems of an optimal combination of mechanical and electronic systems in promising mechanisms, machines and structures.

Control of machines includes problems of control, automation of control, problems of interaction of the operator and object of control (man-machine), including problems under extreme conditions.

Automation in machine building encompasses the scientific problems of automation and robotization of an entire cycle of development and manufacture of machines and structures and of individual components of this cycle, including problems of automation of scientific research work, design of machines and structures, and technological processes of their manufacture.

Essentially new progressive technologies in machine building include the scientific fundamentals of development of essentially new progressive manufacturing processes of shaping the parts of machines and structural elements, assembly and checking of parts, assemblies, machines and structures, and also the technological aspects of improving the quality and reliability of machines and structures.

Experimental mechanics, diagnostics, and testing encompass a wide range of scientific problems of experimental studies of the mechanical characteristics of models and of full-scale specimens of machines, structures and their assemblies, modern methods and means of experimental studies of the reliability, strength and wear resistance of machines and structures, methods and means of diagnosis and flaw detection, problems of the methodology of testing and modification of machines and structures, including those under extreme conditions, and scientific problems of development of the corresponding equipment.

Along with publication of scientific articles on the indicated directions, chronicles about the most interesting events and measures that provide new information about the latest advances of the science of machines and about scientific and technical progress in machine building are envisioned in the journal.

UDC 621.865.8:658

Problems of Creating Optimal Processing Units With Industrial Robots

18610066 Moscow VESTNIK MASHINOSTROYENIYA in Russian No 8, Aug 88 pp 74-76

[Article by doctor of economic sciences, Professor G. Ressel, economist G. Peters, Higher Economic School imeni Bruno Leuschner, Berlin]

[Abstract] Characteristic errors have frequently been made in selecting process units for industrial robots: failure to assure proportional capacity of industrial robots, the machine tools they service and related peripheral devices; failure to structure process units so as to liberate the maximum working force; failure to consider actual present and future demand; failure to provide a path for future expansion of units. This article discusses the principles upon which the design of process units for industrial robots is to be based. Criteria are presented for evaluating machines for use with robots, for evaluating the robots, for evaluating the human workers and their conditions of labor to be used with the robots, for evaluating the organization of the production process and the structure as a whole. The economic, organization and social goals of the use of industrial robots are noted. Overall structuring of process units with industrial robots can reveal productivity reserves to be utilized. The optimality criteria are the productivity, agreement of the process unit with its goals and the use and development of specific production conditions. References 4: East German.

UDC 621.979-11-9

Hydraulic Press for Packaging Metal Wastes

18610159a Moscow KUZNECHNO-STAMPOVOCHNOYE PROIZVODSTVO in Russian No 9, Sep 88 p 22

[Article by B. I. Korneyev]

[Abstract] "Donpressmash" Production Association in Azov has undertaken series production of the model BG1334 press, designed for packaging of sheet production wastes with tensile strength not over 500 MPa and relative elongation at least 15 percent, and also metal scrap. The press uses a rocking cover to force scrap from the receiving hopper downward into the bottom of the machine, where it is further pressed to one side to generate a compact cube. A cross-sectional diagram of the press is presented. A single operator controls the press from an air-conditioned operator's cabin. The press produces packets of steel wastes with a density of up to 3000 kg/m^3.

UDC 621.979.06

New Forging and Pressing Machines for Individual Stamping

18610159b Moscow KUZNECHNO-STAMPOVOCHNOYE PROIZVODSTVO in Russian No 9, Sep 88 pp 23-24

[Article by Yu. A. Miropolskiy and L. P. Ponomarev]

[Abstract] The problem of increasing the efficiency of short-run and individual production processes is being solved in part by individual element stamping, in which, rather than stamping final shapes from sheet metal, elements of the shapes are individually stamped on a range of universal, adjustable stamping machines with rapidly interchangeable tools for the manufacture of contours of parts of various shapes and sizes by a series of individual stamping operations. Such presses have

been created by the Azov Special Design Bureau of forging and pressing equipment and automatic lines. This article describes the parameters, technological capabilities and design specifics of these presses. Further improvement of the design of these presses is continuing in the direction of equipping them with programmed control to set the dimensions of the elements stamped and interchange the stamping tools.

UDC 621.311.658.514.011.56

Branchwide Instruction and Training System for Power Generation System Dispatchers and Operating Personnel of Electrical Networks
18610129 Moscow ELEKTRICHESKIYE STANTSII in Russian No 6, Jun 88 pp 5-8

[Article by A. G. Propopenko, candidate of technical sciences and V. G. Ruchko, N. S. Dolgonosov, G. A. Doroshenko, O. I. Klimenko and V. A. Isayev, engineers, Yuzhtekhenergo, Central Dispatcher Control of the USSR Unified Power Generation System, and southern division of the All-Union State Power Generation and Electric Network Exploratory Design and Scientific Research Institute (Energosetproyekt)]

[Text] The 27th CPSU congress designated creating a state continuing education system as the most important task that must be accomplished during the next few years.[1] The branch operating personnel training system (which is based on training centers and stations at which personnel are trained on simulators) that is currently being developed in the USSR Ministry of Power and Electrification fully meets the requirements of such a system.[2,3]

The branch has already accumulated positive experience in using simulators to train and increase the qualifications of electric power plant operating personnel. The following have been operational for a number of years: a personnel simulator training center to train personnel at the power-generating units of the UkSSR Ministry of Power and Electrification at the Tripolsk GRES (it has an integrated simulator based on M-4030 and M-400 computers[4]); a personnel simulator training station to train electric power plant personnel at the Moscow Rayon Power Generation Administration TETs-25[5]; and simulators at the Konakova GRES, Lukomlsk GRES, Berezovka GRES, Novocherkassk GRES, etc. A personnel simulator training center is being designed and constructed at the Ekibastuz GRES, and personnel simulator training stations are being designed and constructed at the Nizhnevartovsk GRES, Ladyzhin GRES, etc.

Training electrical network dispatchers at the power generation system [EES], enterprise [PES], and rayon [RES] levels as well as shift engineers and linesmen at substations and traveling operating crews is an important task. In accordance with a program to create a regional training and instruction system for operating personnel of the UkSSR's power generation system, personnel simulator training centers are now being created at the Dneprovsk Rayon Power Generation Administration [Dneproenergo], Kiev Rayon Power Generation Administration [Kievenergo], and Kiev cable networks. A number of organizations (the All-Union Electrical Power Generation Scientific Research Institute [VNIIE], Central Dispatcher Administration of the USSR Unified Power Generation System [TsDU YeES SSSR], the Siberia and Ural centralized dispatcher controls [ODU], the Leningrad branch of the All-Union Institute for Increasing the Qualifications of Managerial Workers and Specialists in the Power Generation Industry [VIPKenergo], and Kiev Polytechnic Institute) are involved in the developing computer-based simulators to train power generation system dispatchers and enterprise electrical network operating personnel to perform routine switchings. The main directions for formulating a subsystem to train the operating personnel of power generation systems and electrical networks have been determined on the basis of many years of experience in training and instructing operating personnel. This subsystem should be a complex of instructional hardware, educational methods materials, teachers and instructors, i.e., a unified total structure for training and increasing and maintaining the professional qualifications of operating personnel. The branch operating personnel training system for power generation systems and electrical networks is a component part of the USSR Ministry of Power and Electrification's branch operating personnel training system.

The main functional elements of the branch operating personnel training system for power generation systems and electrical networks should be as follows: personnel simulator training centers, power generation system simulator training stations, and power generation system testing and training posts, as well as power generation system central dispatcher service testing and training posts.

Figure 1 diagrams the functioning of the branch operating personnel training system for power generation systems and electrical networks. The organizational and methodological (dashed lines) ties between the system's functional nodes are reflected in the diagram.

It would be advisable to organize two regional personnel simulator training centers in the branch—a western center in the Donets Coal Basin Rayon Power Generation Administration and an eastern center in the UzSSR Ministry of Power and Electrification—as well as one personnel simulator training center based at the Leningrad branch of the All-Union Institute for Increasing the Qualifications of Managerial Workers and Specialists in the Power Generation Industry. The latter would be responsible for methodological control of the regional EES personnel simulator training centers and personnel simulator training stations (power generation system testing and training posts) and the central dispatcher service testing and training posts. EES personnel simulator training stations (testing and training posts) should be created in each power generation system (with the exception of those power generation systems that have personnel simulator training centers and central dispatcher service testing and training posts) as well as in the centralized dispatcher controls and central dispatcher controls.

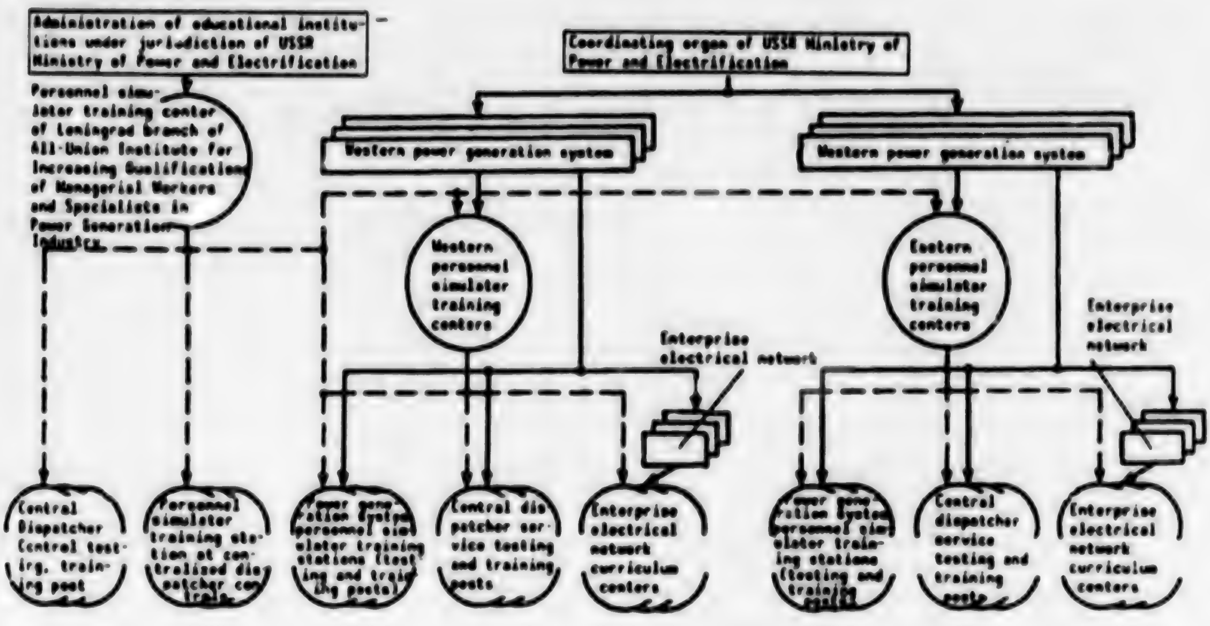

Figure 1. Structure of the Functioning of the Branch Operating Personnel Training System for Power Generation Systems and Electrical Networks

The purposes of a regional personnel simulator training center are as follows: train and increase the qualifications of the dispatchers working in a region's power generation systems and enterprise-level electrical networks; coordinate the operation of EES personnel simulator training stations (testing and training posts) and the central dispatcher service testing and training posts; and train and then maintain and increase the qualifications of all of the operating personnel working in the electrical networks of that power generation system.

Power generation system electrical network-level (i.e., EES-level) personnel simulator training stations (testing and training posts) are intended to train as well as to maintain and increase the qualifications of enterprise electrical network-level dispatchers, shift engineers, substation linesmen, and linesmen in traveling operating crews of that particular power generation system.

The central dispatcher service testing and training post is involved in training and increasing qualifications and in ongoing testing and maintenance of the qualifications of dispatchers in its own power generation system and enterprise electrical network.

Ongoing testing of operating and dispatch personnel should be implemented in the following manner. Dispatchers from the central dispatcher control and centralized dispatcher control of the REU [not further identified] PEO [not further identified], and enterprise electrical network periodically visit the central dispatcher service testing and training post. There they undergo ongoing testing and receive the required training. In view of the large number of other types of operating personnel and the lack of territorial coordination, other operating personnel are tested and trained with the help of mobile testing and training posts, which should be included as a component of the EES-level personnel simulator training stations (testing and training posts). Enterprise electrical network-level curriculum centers, which are now functioning in a number of power generation systems, should be included as components of the branch operating personnel training systems for power generation systems and electrical networks. Table 1 presents recommendations for using training facilities when training and improving the qualifications of operating personnel.

Personnel training in the branch operating personnel training system for power generation systems and electrical networks should be conducted in accordance with the requirements of existing normative materials[6] dealing with personnel work. Depending on the trainee's occupation, training is conducted at either a personnel simulator training station (testing and training post) or a personnel simulator training center (in the case of power generation system and enterprise electrical network dispatchers), or else on-the-job training is provided at the power generation system's facilities. After the trainee passes an examination and after doubling up with another worker, the trainee is permitted to work independently. Figure 2 presents the recommended scheme for training enterprise electrical network dispatchers.

It would be well to base a branch operating personnel training system for power generation systems and electrical networks on the following principles:

Table 1.

Occupation	Training Facility							
	[illegible]	Regional personnel simulator training center	Testing and training post, central dispatcher control	Testing and training post, centralized dispatcher control	Testing and training post, [illegible] dispatcher	[illegible]	Curriculum center, enterprise electrical network	Workstation
Central dispatcher control dispatcher	+	—	+	—	—	—	—	+
Centralized dispatcher control dispatcher	+	—	—	+	—	—		+
PEO (REU) dispatcher	+*	+*	—	—	+	—	—	+
PES dispatcher	—*	+*	—	—	+	—	—	+
Rayon electrical network dispatcher	—	+**	—	—	—	+	—	+
Substation shift engineer	—	+**	—	—	—	+	—	+
Substation shift lineman	—	+**	—	—	—	+	—	+
Shift lineman of traveling operating crews working at substation	—	+**	—	—	—	+	—	+
Shift linemen of traveling operating crews working in distribution	—	+**	—	—	—	+	+***	+

*: on dispatchers in its own area; **: electrical network personnel in the power generation system in which the personnel simulator training center is located; ***: if they are not trained in EES-level personnel simulator training stations [testing and training posts]

the system being created should not replace but rather should develop and improve the practice of training and maintaining the qualifications of power generation system dispatch personnel and electrical network operating personnel;

—training programs for operating personnel should be based on the main tasks (as identified in an analysis) entails in each operation-related activity for each occupation;

—improvements in training and maintaining and increasing the qualifications of operating personnel should be based on the wide-scale introduction of modern testing equipment and computer-based simulators and on advanced psychological and pedagogical training methods and on programmed- and algorithm-type instructional materials;

—personnel work should be based on established measurable professional qualifications norms and on regular monitoring of the status of a person's degree of training and the restoration of lost knowledge and skills by training;

—when creating a branch operating personnel training system for power generation systems and electrical networks, it is advisable, first and foremost, to use the computer technology that currently exists in the central dispatcher controls and centralized dispatcher control, power generation systems, and enterprise electrical networks.

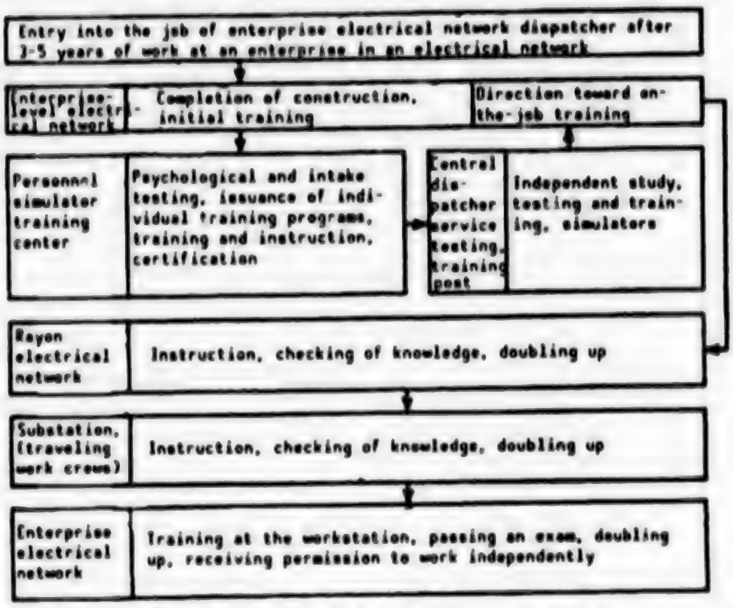

Figure 2. Recommended Scheme for Training Enterprise Electrical Network Dispatchers

Tables 2 and 3 present recommendations concerning the make-up of training and instruction hardware and curriculum materials with which the training facilities of the branch operating personnel training system for power generation systems and electrical networks should be provided. Using computers makes it possible to centralize the preparation of instructional and methodological materials in the personnel simulator training centers n machine information carriers and to subsequently disseminate them to the regional personnel simulator training stations, curriculum centers, etc.

A branch operating personnel training system for power generation systems and electrical networks should be provided with a special system to control the quality of training and maintenance/improvement of qualifications that is geared toward managing instructional content and the instructional process.[7] Managing instructional content requires the creation of the respective qualifications characteristics in specialists, curricula, and instructional programs as well as the constant sampling and correction of instructional content. It would be advisable to base the management of the instructional process of psychological and pedagogical principles of organizing and designing and instructional process by using the instructional hardware developed at Moscow State University.[8]

The aforementioned principles of the design and functioning of a branch operating personnel training system for power generation systems and electrical networks have been developed by a group of organizations in which the Yuzhtekhenergo, Central Dispatcher Control of the USSR Unified Power Generation System, and Energosetproyekt participated. The principles have been implemented in the General Scheme for Distributing Facilities To Train Operating Personnel of the Power Generation Enterprises and Dispatcher Controls in the USSR Ministry of Power and Electrification.

Hardware	Component base	Training facilities				
		Testing and training posts of central dispatcher control and centralized dispatcher control	Personnel simulator training centers	EES personnel simulator training station, EES testing and training post	Central Dispatcher Service testing and training post	Enterprise electrical network curriculum center
Programmed guides	Brochure materials	−	+	+	+	+
Programmed lectures	Same	−	+	+	−	+
Programmed seminary study	» »	−	+	+	−	+
Situation evaluation trees	Instructional program. Description containing graphs	+ + −	+ + +	+ + −	+ + +	− + −
Observation charts	Instructional program. Description containing graphs	−	+	−	+	−
Plans of action	Instructional program. Description containing graphs	+ +	+ +	+ +	+ +	− +
Quiz and training exercises	Instructional program. Description containing graphs	+ +	+ +	+ +	+ +	− +
Operating documentation	Instructions, diagrams, descriptions	+	+	+	+	+
Laboratory work	Brochure materials	−	+	+	−	+

Table 3.

Hardware	Component base	Training facilities: Testing and training posts of central dispatcher control and centralized dispatcher control	Personnel simulator training centers	EES personnel simulator training station, EES testing and training post	Central Dispatcher Service, testing and training post	Enterprise electrical network curriculum center
Equipment set for psychological testing	Hardware, microcomputers	— +	+ +	+ +	— +	+ —
Automated group instruction class	Hardware	—	+	+	—	+
Equipment complex for individual testing and instruction	CM-1420, personal microcomputers	+ —	+ —	— +	+ —	— —
Specialized simulators	CM-1420, EC-1011, microcomputers	+ + —	+ + +	— + +	+ + —	— + +
Operating conditions simulator	CM-1420, EC-1011	+	+	—	+	—
Simulator for routine switchings	CM-1420, hardware, microcomputer	— — —	+ — —	— + —	+ — —	— — +
Audiovisual aids	Hardware	+	+	+	+	+
Polygons of routine switchings	Real equipment	—	+	+	—	+
Existing stands, mock-ups	Hardware	—	+	+	—	+
Mobile testing and training post	Microcomputers, transport	—	+	+	—	—

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UDC 621.873.7

Structure on Deck of 140-Ton Floating Crane

18610349a Leningrad SUDOSTROYENIYE in Russian No 11, Nov 88 pp 10-15

[Article by G. I. Rudak and Yu. N. Mokhov]

[Abstract] The third 140-ton floating crane was built and delivered by the Industrial Association "Sevastopol Marine Equipment Manufacturing Plant imeni S. Ordzhonikidze", the first of these cranes intended for replacement of the existing 100-ton "Chernomorets". It consists of a main derrick and an auxiliary one, each capable of using an additional boom for tackling and pulling. The equipment is designed for operation at air temperatures plus or minus 30 deg C, with high-strength material capable of withstanding impact by waves on a scale of 3 and winds of force 4 on the scale. Its entire super structure, including the operations room, has been inspected and underwent comprehensive testing upon delivery. Figures 9; references 2: Russian.

UDC 629.12'313'

Construction of Comprehensively Automated Future Ships

18610349b Leningrad SUDOSTROYENIYE in Russian No 11, Nov 88 pp 20-23

[Article by V. M. Korchanov, manager, 'Comprehensive Automation of Ships' Section, Leningrad Regional Board, All-Union Scientific and Technical Society imeni Academician A. N. Krylov]

[Abstract] Use of computers and microprocessors for eventual comprehensive automation of ships is discussed, the USSR lagging seriously behind Japan and West European shipbuilding countries (England, Norway, FRG). Comprehensive automation includes automatic ship guidance, dynamic stabilization, power processes, biotechnical processes, navigation, and housekeeping activity. Contribution of the All-Union Scientific and Technical Society, particularly its Leningrad Regional Board as well as its Central Board and other regional boards, is overviewed with emphasis on organizational involvement. A major problem is lack of clear division of responsibility for marine automation hardware, marine radioelectronic equipment, and automation of hardware production at manufacturing enterprises. The Society's role in solving problems of ship automation, is seen in establishing two separate sections responsible for design of marine instruments and for their manufacture. Figures 1; tables 1; references 8: 2 Russian, 6 Western.

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